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ABSTRACT

This post high school program development guide considers the following natural resources technological areas: air pollution control, forest, rangeland, minerals and mineral fuels, geological, outdoor recreation, soil, urban-regional planning, landscape, water, wastewater, oceanography, wildlife, fish, and marine life. Within each area, the following topics are discussed: (1) definition, scope, and environmental significance of the resources; (2) a discussion of the competencies required, personal qualities, position titles, and typical duties, types of employers, and employment outlook for technicians educated in the resource area; (3) suggested technical curriculua, including general program considerations, course title and sequence, and brief course descriptions; (4) selected references on the resource, technical, and occupational positions; and (5) a list of selected professional and technical organizations. (Author)

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NATURAL RESOURCES TECHNOLOGIES

A Suggested Post High School

Program Development Guide

CE002 571

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FOREWORD

Career education is a comprehensive, systematic, and cohesive plan of instruction that provides each student the opportunity to plan and prepare for a meaningful and satisfying role as a working member of society. Occupational clusters, representative of the entire world of work and around which a career education system can be designed were identified by the U.S. Office of Education. The 15 occupational clusters are:

- business and office
- marketing and distribution
- communications and media
- construction
- manufacturing
- transportation
- agribusiness and natural resources
- consumer and homemaking-related
- environmental control
- public services
- health
- hospitality and recreation
- personal service
- fine arts and humanities
- marine science

This program development guide is one of four publications developed by the Department of Agricultural Education, College of Agriculture, The Pennsylvania State University, as a result of a project entitled "Career Education in the Natural Resources." The project was funded under a grant from the Division of Vocational and Technical Education, Office of Education, U.S. Department of Health, Education, and Welfare.

The project grew out of a need for materials offering strategies for implementing career development programs in the field of natural resources, a part of one occupational cluster. Although there was an abundance of information concerning vocational development theories, there was an apparent shortage of materials offering strategies for implementing these theories into operational programs. This void was causing considerable frustration to practitioners who were attempting to design and implement the career education concept in their schools and communities.

The purposes of the overall project were: (1) to develop appropriate curriculum guides in the natural resources suggesting a sequentially-developed education program offering career awareness, career exploration, and job preparation; (2) to acquaint educational leadership in all states with the curriculum materials resulting from this project and promote their use; and (3) to disseminate copies of the curriculum materials produced in the project in the states.

Regional Workshops were held during May and June, 1973 in nine of the Regional Offices of the U.S. Office of Education in the following cities: Boston, Philadelphia, Atlanta, Chicago, Dallas, Kansas City, Denver, San Francisco, and Seattle. These meetings were attended by more than 300 classroom teachers, guidance counselors, school administrators, teacher educators, and state education department personnel, who were acquainted with the outcomes of the project, reviewed the guide, and were instructed in its effective use and implementation in a local program. Participants made recommendations for improving the guide and for the purposes of meeting the variations in needs and practices across the country. These recommendations are reflected in this final document.

The technological programs at the 2-year post high school level must provide occupational and technical knowledge and applied skills that permit the graduates to secure employment in the technical aspects of natural resources management or to become self-employed (Figure 1.) In recent years, technicians have been one of the fastest growing occupational groups. The demand for natural resources technicians is expected to increase because the wise use of natural resources will continue to be essential for the health, security, and prosperity of the nation.

Other curriculum materials resulting from this project area:

Natural Resources and Career Awareness
A Teacher's Guide for Grades K-6

Exploring Occupations in the Natural Resources
A Student Resource Guide for the Middle School

Occupational Preparation in the Natural Resources
A Suggested High School Curriculum Guide

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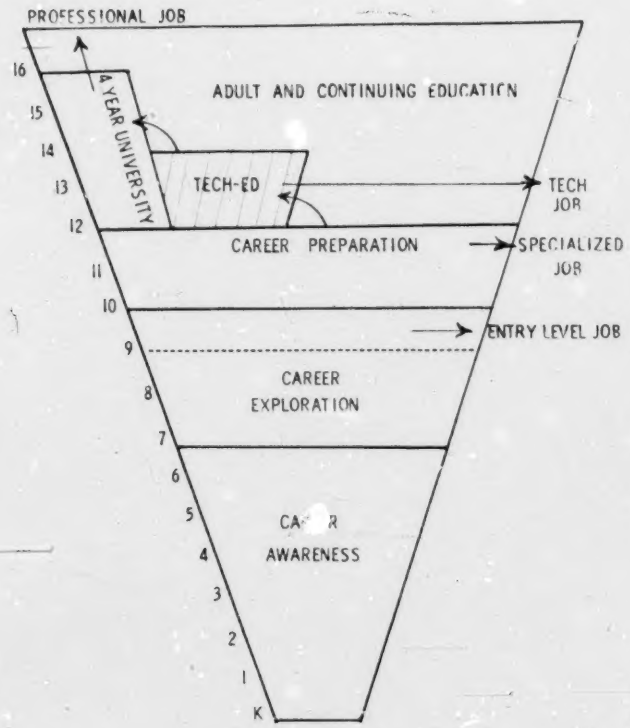

Figure 1 – Career Education. From U.S. Department of Health, Education, and Welfare, Office of Education. *Career Education: A Model For Implementation,* Draft April 1971.

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USE OF THIS GUIDE

This guide considers the following natural resources technological areas: Air Pollution Control, Forest, Rangeland, Minerals and Mineral Fuels, Geological, Outdoor Recreation, Soil, Urban-Regional Planning, Landscape Architecture, Water, Wastewater, Oceanography, Wildlife, Fish, and Marine Life. In each natural resource technology, the following subjects are discussed: (1) definition, scope, and environmental significance of the resources; (2) a discussion of the competencies required, personal qualities, position titles, and typical duties, types of employers, and employment outlook for technicians educated in the resource area; (3) suggested technical curricula, including general program considerations, course titles and sequence, and brief course descriptions; (4) selected references on the resource and technical and occupational positions; and (5) a list of selected professional and technical organizations.

Administrators of post-secondary institutions who are contemplating the establishment of technical programs in natural resources will find this suggested program development guide useful in several ways. The definition and scope of each natural resource will enable the administrator to identify and delimit each natural resource in the region served by his institution. The environmental significance of the resource will provide the administrator with information which can be used in the formal justification of the proposed technical program to boards of regents, boards of college trustees, and other college advisory and administrative organizations.

A consideration of the competencies and personal qualities needed in technician graduates of a specific natural resource program will be valuable to the dean of admissions and other college recruitment personnel. This information will provide guidelines to the desirable characteristics for potential students admitted to a new technical program in natural resources.

The position titles and typical duties section guides the administrator in the kinds of "hands on" laboratory experiences required by technical students.

The discussion of types of employers of technicians in each natural resource area is important to the administrator for several reasons. This section provides a starting point for the administrator in his necessary location and recruitment of persons to serve on the advisory committee. The advisory committee is a critical ingredient for a successful technical program in any natural resources area. It is composed of professional scientists, managers, and administrators in government, academia, and industry who are engaged in the management of the particular natural resource. This committee assists the educational institutions in developing and revising the technical curriculum in the specific natural resource, determining the desired characteristics of the technical students, projecting the employment demand for the technical graduate, and providing facilities for the student's work experience. When feasible, the same members might serve on both the high school and post high school advisory committees to facilitate articulation.

The course titles and sequence provide the administrator with a general concept of the types of courses required to educate technicians in a given natural resource technology, and a method of integrating these courses into a logical four-semester sequence. The brief course descriptions provide information on the basic knowledge which is to be imparted to the technical students. Variations in course titles, sequence, and content are inevitable because of differences in geographical location and types of post-secondary institutions, composition of the advisory committee, faculty competence, and so on. It should be stressed that, since technician education is job-oriented, it is critically important that technical students are provided with the most up-to-date technological equipment, techniques, and instruction.

Some of the natural resources discussed in the suggested program development guide, such as Forest and Rangeland, are closely related. If the educational institution is located in a geographical area where both forests and rangelands are important natural resources, it would be feasible to offer educational programs in both of these areas, since the two curricula have many courses in common.

The list of selected references provides the administrator with an initial starting point for gathering more detailed information concerning the specific natural resource and technician education and qualifications. The list of selected professional and technical organizations provides sources of employment information, technical and scientific literature, and other information.

The effectiveness of the program depends largely upon the competence and the enthusiasm of the teaching staff. The specialized nature of these programs requires that instructors have special competence based on proficiency in technical subject matter as well as practical experience in their subject area.

Supporting facilities for a technological program in the natural resources must be carefully planned and may be quite expensive. Instructors should be involved in the planning process. Whenever possible, established programs should be studied and visited, and staff with successful programs need to be consulted.

DISCRIMINATION PROHIBITED - Title VI of the Civil Rights Act of 1964 states: "No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subject to discrimination under any program or activity receiving Federal financial assistance." Therefore, the Vocational Education program, like every program or activity receiving financial assistance from the Department of Health, Education, and Welfare, must be operated in compliance with this law.

Titles of all curriculum materials resulting from the project, "Career Education in the Natural Resources," grant No. OEG-0-71-4432 (357) are listed below.

Natural Resources and Career Awareness
A Teacher's Guide for Grades K-6

Exploring Occupations in the Natural Resources
A Student Resource Guide for the Middle School

Occupational Preparation in the Natural Resources
A Suggested High School Curriculum Guide

Natural Resources Technologies
A Suggested Post High School Program Development Guide

(This page was retyped at the ERIC Clearinghouse in Career Education due to the non-reproducibility of the original.)

Chapter 1
INTRODUCTION

Programs to educate highly skilled technicians are increasing in number, size, and variety in response to the need for a more widely shared and greatly expanded technical competence to cope with the demands of an increasingly sophisticated technology. The education of technicians was until recently not recognized as so essential as to require the involvement of a large number of educational institutions. The education of technicians has been limited for many years to a small number of community colleges and technical institutes. Because the number of institutions had been small, the special nature of technician education programs is not generally known to many administrators of post-secondary programs who are now required to consider inititating them.[1]

The explosive growth of community colleges across the country, and the concurrent national emphasis on post-high school vocational and technical education, have great significance for agriculture and natural resources.[2] Between 1966 and 1970, the most spectacular enrollment increases in post-secondary occupational education occurred in agriculture and natural resources.[3] In the academic year 1967-1968, there were 13,759 students enrolled in two-year technical programs in agriculture and natural sources in 197 institutions. When the student enrollment is apportioned between agriculture and natural resources, however, it was seen that only about 15 percent of the students were enrolled in natural resources curricula (Forestry, Wood Utilization, Fisheries and Wildlife, Outdoor Recreation, and Soil Technologies) while the remainder of the students were enrolled in the traditional production agriculture areas (Agricultural Business, Ornamental Horticulture, Agricultural Engineering, Animal and Poultry, Crop, Food, and related agricultural technologies).[4]

Recent technological advances in the management of the nation's natural resources have resulted in a shortage of highly trained technicians. These technicians are needed to assist professional scientists, managers, and administrators in the important task of developing, maintaining, regulating, and protecting our natural resources. The demand for natural resources technicians is expected to increase.

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[4] Panel on Two-Year Programs. Commission on Education in Agriculture and Natural Resources. National Academy of Sciences. "Technical Education in Agriculture and Natural Resources." *Journal of the National Association of Colleges and Teachers of Agriculture,* Vol. 15, No. 2: 35-42. June, 1971.

Chapter 2

AIR POLLUTION CONTROL TECHNOLOGY

DEFINITION

Air is defined as the mixture of gases which comprise the earth's atmosphere. Nitrogen and oxygen are the major constituents of air, comprising 78 and 21 percent respectively. The remainder of "pure" air consists of carbon dioxide, inert gases (argon, helium, krypton, neon, and xenon), water vapor, and particulate matter (volcanic dust, pollen, small biota, etc.)

SCOPE

For the purpose of this publication, the scope of air will be limited to the troposphere, a layer of air which is about 10 miles thick at the equator and five miles thick at the poles. The discussion of air pollution will be limited to man-made contamination of community or ambient air as distinguished from occupational air (the air within an industrial installation.)

ENVIRONMENTAL SIGNIFICANCE

Air contains numerous elements and compounds which are essential for the maintenance of biological organisms. The oxygen of the air is necessary for normal aerobic respiration by terrestrial plants and animals. The dissolved oxygen utilized by aquatic and marine biota was derived from the troposphere and the photosynthetic activities of aquatic flora. Nitrogen is the critical element in the chemical composition of amino acids, which comprise all proteins. Air is the greatest reservoir of nitrogen. Nitrogen-fixing bacteria in the soil and blue-green algae in aquatic environments extract nitrogen from the air and convert it to a form which can be utilized by green plants for producing proteins, sugars, fats, and various secondary compounds. A portion of the nitrogen in plant tissues passes on to herbivores and subsequently to one or more groups of carnivores. The microorganisms of decay release nitrogen from the tissues of dead organisms and it returns to the air reservoir. The carbon dioxide of the air is combined with water in green plants to provide the raw materials for photosynthesis, the basic process on which nearly all life on earth ultimately depends. The oxygen supply of the air is replenished by photosynthesis.

The troposphere is an important component of the water or hydrologic cycle and serves as the medium for the distribution of precipitation over the earth. The solar light energy is absorbed by the earth and reradiated to the atmosphere as heat energy which is responsible, together with the earth's orientation to the sun and its rotation, for the earth's climate, weather, and wind patterns.

Human activities have been contaminating the atmosphere for thousands of years. Throughout the earlier periods of history, wood was utilized to provide energy for domestic and industrial needs. The small and dispersed human population and simple industries did not cause appreciable air pollution. A gradual transition from wood to coal as the primary source of energy culminated in the Industrial Revolution, starting around 1300 A.D. and continuing to the present time. The increase in the human population, the development of cities, and industrial expansion eventually resulted in damaging levels of air pollution.

The implications of air pollution to public health were not recognized until catastrophic air pollution incidents caused hundreds of human deaths. Air pollution development in England provides an interesting case history. The British government became concerned about the smoke and odors associated with the combustion of coal in England's industrial towns in the 1400s, when King Henry V attempted to regulate the amount of coal entering London. During the last 500 years, intermittent studies of air pollution have been conducted and various kinds of air pollution control regulations have been enacted. However, no effective governmental action was taken until air pollution killed 4,000 people and sickened thousands of others in London in December, 1952.

Industrial smoke and gases attributable to coal-based industries in the United States initiated effective public pressure for successful community-based air pollution abatement programs in St. Louis and Cincinnati prior to World War II. The increased industrial development stimulated by the war resulted in an accelerated rate of deterioration of air quality. Twenty persons were killed and 5,900 became ill because of a high level of air pollution in Donora, Pennsylvania, in 1948. Epidemiological studies have indicated that hundreds of persons died from the effects of air pollution in New York City in 1953, 1962, 1963, and 1966.

The use of petroleum and natural gas for domestic, industrial and transportation energy sources has added a new dimension to air pollution. In 1945, the first community air pollution problem attributable to petroleum energy sources was discerned in Los Angeles. Volatile organic hydrocarbons and various oxides of nitrogen are released into the air by petroleum manufacturing and by use of petroleum-based fuels. These pollutants do not possess high toxicity to organisms. In the presence of sunlight, these materials interact with each other and with other reactive gases in the air to form a variety of intermediate and terminal products, such as ozone, organic hydroperoxides, peroxyacyl nitrates or nitrites, and aldehydes. The type and proportions of photochemically-mediated intermediate and end products depend upon variations in environmental factors such as concentration, humidity, temperature, and other gases present in the air. Some of these photochemical reaction products are toxic to living organisms at very low concentrations.

In the United States air pollution is a problem in all large cities as well as their suburbs and nearby towns. Each year over 200 million tons of man-made waste products are released into the air in the United States. Estimates from 1969 show that, in terms of weight, 51 percent of these pollutants come from transportation sources, 16 percent from fuel combustion in stationary sources, 15 percent from industrial processes, 4 percent from solid waste disposal practices, and 14 percent from miscellaneous sources. It should be noted that weight of pollutants is not necessarily in all cases the best indication of their importance.

At levels commonly found in urban areas, air pollution contributes to the incidence of such chronic diseases as emphysema, bronchitis, and asthma. Recent research has shown that air pollution may be a contributing factor in lung cancer. All of these diseases have increased markedly in recent decades.

The adverse economic effects of air pollution are much more varied and substantial than is generally realized. They range from the waste of fuel and other valuable resources, through the soiling and corrosion of physical structures of all kinds, to damage to agricultural crops, ornamental plants, and forests. Moreover, by reducing visibility, air pollution contributes to the toll of accidents in both air and ground travel.

Air pollutants may be divided into two groups: (1) Primary pollutants: those emitted directly from identifiable sources; (2) Secondary pollutants: those formed in the air by interaction of two or more primary pollutants, or by reaction with normal atmospheric constituents. A brief consideration of some of the major pollutants and their detrimental effects on environmental quality will serve to emphasize the necessity of air pollution abatement.

Primary pollutants include sulfur compounds, carbon compounds, hydrocarbons, nitric oxide, and fluorides.

Sulfur is a common contaminant of coal and fuel oil used for domestic and industrial energy. The combustion of sulfur produces large amounts of sulfur dioxide and lesser amounts of sulfur trioxide. Industrial operations and waste incineration produce hydrogen sulfide, and mercaptans are evolved through the activities of the pulp and paper and petroleum industries. Sulfur dioxide can irritate the upper respiratory tract of man and cause chlorosis of leaves of plants. Hydrogen sulfide has a noxious odor and causes deterioration of paint and silver utensils. The reactions of sulfur compounds as secondary pollutants will be discussed later.

Carbon is a common element of fossil fuels and many other compounds. Very fine carbon particles, known as soot, are very prevalent near sources of combustion. Soot particles often carry other pollutant compounds absorbed to their surface. Carbon monoxide is a colorless, odorless, highly toxic gas produced mainly by incomplete combustion in the internal combustion engines of motor vehicles. Carbon monoxide often exceeds safety levels on urban streets. Carbon dioxide is formed as the end product of complete combustion in motor vehicles and is also released naturally from decaying organic matter.

Hydrocarbons are composed of various proportions of carbon and hydrogen; some hydrocarbons contain reactive radicals. The olefin groups of unsaturated hydrocarbons, and the aromatic group of cyclic, unsaturated hydrocarbons are the most important air pollutants among the hydrocarbons. Industrial combustion and motor vehicles are the most important sources of hydrocarbon pollutants. Many other industrial operations emit hydrocarbons into the atmosphere. Some olefins adversely affect plant growth and many aromatic compounds are carcinogenic in man and animals.

High-temperature combustion results in the formation of nitric oxide. Motor vehicles and electric power plants are the major source of this gas. Nitric oxide owes its importance in air pollution to its reaction as a secondary pollutant.

Fluoride compounds occur commonly in ores, soils, and vegetation. The ceramics, iron and steel, aluminum, and fertilizer industries emit fluorides as gases or solid particles. Fluoride air pollutants damage vegetation. Some plant species can accumulate fluorides and cause sickness or death in livestock which consume the plants as forage.

Secondary air pollutants include sulfur compounds, carbon compounds, hydrocarbons, nitrogen dioxide, ozone, peroxyacyl nitrate, and aldehydes.

Sulfur dioxide combines with water vapor in the air to form sulfurous acid. When sulfur dioxide is oxidized to sulfur trioxide, it can then unite with water vapor to form sulfuric acid. These two acids cause irritation of man's respiratory tract, chlorosis of vegetation, deterioration of paint, iron, steel, paper, and stone.

Carbon dioxide (a naturally occurring compound in air), combines with water vapor in the air to form carbonic acid which causes normal deterioration of stone, magnesium, and other metals.

Hydrocarbons form a large number of compounds via photochemical reactions with other air pollutants such as nitrogen oxide, halogens, and aldehydes.

Hydrocarbons and sunlight catalyze the rapid conversion of nitric oxide to the more dangerous nitrogen dioxide. Nitrogen dioxide has a yellow-brown color and contributes significantly to reducing visibility. Nitrogen dioxide combines with water vapor in the air to form nitric acid which corrodes metals.

Ozone is a product of solar irradiation of the atmosphere. Ozone provides a source of oxygen for atmospheric oxidations. Ozone is very irritating to man's respiratory tract and may cause fatigue. It damages vegetation and causes deterioration of rubber, fabrics, and colors.

Peroxyacyl nitrate (PAN) is a photochemical reaction product which irritates man's eyes and lungs and damages vegetation.

Aldehydes are formed by the combination of hydrocarbons and oxygen. Aldehydes cause severe irritation of man's eyes, respiratory tract, and skin.

It is anticipated that nuclear power plants will gradually replace most of our coal-based power installations. Therefore, the potential danger from the accidental release of radioactive materials from nuclear power plants can be predicted to increase. Pesticides, asbestos, and several metallic elements (lead, mercury, beryllium, arsenic, etc.) are air pollutants whose potential threat to the environment and public health are still imperfectly known.

The first regional effort to study, monitor, and control air pollution was the establishment of the Los Angeles County Air Pollution Control District by the California Legislature in 1947. This outstanding organization conducted much of the pioneering research on atmospheric pollution, especially in the area of photochemical oxidation.

The first Federal program on air pollution was developed in 1955 when the Public Health Service conducted a modest air pollution survey and offered technical assistance to State and local governments, which traditionally have had primary responsibility for dealing with community air pollution problems.

In 1963 Congress passed the Clean Air Act. This law authorized financial assistance to State and local governments for the initiation and improvement of control programs, Federal interstate abatement actions, and the publications of criteria describing the effects of pollution. The law placed special emphasis on gaseous pollutants, particularly exhaust emissions from motor vehicles and sulfur oxides from stationary sources.

In 1965, amendments to the Clean Air Act gave the Federal program authority to curb motor vehicle emissions. Federal standards were first applied to 1968 model motor vehicles.

The Air Quality Act of 1967 authorized the Public Health Service to establish atmospheric areas over the entire Nation in which meterorological, topographic, and climatological conditions affecting the dispersal of air pollutants were similar. It also authorizes the publication of documents describing the effects of pollutants, accompanied by data on types and costs of techniques available to carry out control at the source. Governors were required to establish air quality standards and implementation plans for regions designated.

The Clean Air Act Amendments of 1970 delegated specific responsibilities to the newly established (1970) Environmental Protection Agency (EPA). In 1971 EPA established national ambient air quality standards specifying the maximum permissible levels in ambient air of the six principal classes of air pollutants: particulate matter, sulfur oxides, hydrocarbons, carbon monoxide, photochemical oxidants, and nitrogen oxides. These comprise primary standards, required to protect public health, and secondary standards (requiring further reduction in particulates and sulfur oxides). States must carry out approved implementation plans for limiting the emission of pollutants so as to achieve the primary standards by 1975 and to achieve the secondary standards within a reasonable period of time. If any state should fail to develop or carry out such plans, EPA is authorized to do so. EPA establishes and enforces performance standards limiting emissions from new or modified stationary sources of pollution. The first such performance standards issued cover large steam-electric generating plants, municipal incinerators, cement factories, and sulfuric and nitric acid plants. EPA establishes and enforces Federal emission standards for pollutants that, while not necessarily widespread, are exceptionally hazardous to human health. Standards limiting emissions of beryllium, mercury, and asbestos were promulgated in 1971. EPA establishes and enforces emission standards for new motor vehicles. Standards have been promulgated requiring a reduction of 90 percent in hydrocarbons and carbon monoxide emitted by 1975 models as compared with the 1970 requirements and a 90 percent reduction in oxides of nitrogen by 1976. EPA may regulate or prohibit the manufacture or sale of fuel additives that result in harmful emissions or interfere with motor vehicle pollution control devices. The first such regulations will cover alkyl lead. Research is

being stepped up and incentives are provided to encourage the early development of low-polluting motor vehicle propulsion systems, including government purchase and use of vehicles employing such systems. EPA is investigating the effects and control of aircraft emissions and published emission standards for aircraft in 1971, to be enforced by the Secretary of Transportation. Citizens are specifically authorized to take civil court action against private or governmental officials failing to carry out the provisions of the law. Public hearings are required at various steps in the standards establishment, enforcement, and regulatory procedures to enable all interested persons to make their feelings known. EPA conducts extensive research into all aspects of air pollution, both in its own laboratories and through grants and contracts. It constructs and operates demonstration plants or processes, or financially assists such projects. Funds are allocated to state, interstate, and local agencies to aid their air pollution control programs.

A nation-wide system of monitoring stations for air pollutants is being established. The stations may be manually operated or fully automatic and may be controlled by Federal, state, or local governments. Data from many of the stations are fed into the national air pollution data bank. These data will permit the detection of increases in pollution levels that may require the issuing of an air pollution alert in order to protect public health.

Several types of air pollution control equipment are available. Electrical precipitators remove particulate pollutants from air or gas streams at stationary emission sources. An electrical charge is imparted to the particulate matter and an opposite charge is placed on metal plates over which the air stream flows. The pollutants flocculate on the plates. Coarse particulate matter may be filtered out by passing the air stream through fine cloth bags. Fume burners are very high temperature ovens which consume combustible waste gases. Settling chambers utilize the principle of gravity action on particulate matter by reducing the velocity of the air stream. Particulate laden gas may be cleaned by spraying it with water in an enclosed chamber. Absorbers are composed of a series of cylindrical towers, each containing and appropriate absorbant chemical for a specific gaseous pollutant. Absorbers utilize the high surface area of activated carbon to remove pollutants from the air stream.

TECHNICAL POSITION REQUIREMENTS

The commitment of the American people to the attainment of clean air, as embodied in the Air Quality Act of 1967 and the Clean Air Act Amendments of 1970, will require the immediate recruitment and training of air pollution control technicians. These personnel are needed to assist environmental protection specialists, engineers, sanitarians, meteorologists, and environmental health scientists in reducing and regulating air pollution in order to protect human health, food and fiber supplies, and property. Air pollution control activities have required and probably will continue to require a large amount of technical work between the industrial personnel charged with reducing air pollution levels to appropriate air quality standards and the Federal and state air pollution specialists charged with enforcing these standards. This technical work has been done by persons who usually have not had any formal education in air pollution control but were trained on-the-job.

Competencies Required

Air pollution control technicians must be capable of working and communicating with professional scientists and engineers as well as industrial plant officials, state and local government representatives, and the general public. Highly skilled technicians must be capable of supervising and coordinating the efforts of skilled workmen. Some air pollution control technicians perform manipulative tasks while others supervise the application of such skills, but most do both. Their work is distinguished from that of the skilled worker primarily in that it is less repetitive, involves more objective analysis and problem solving, and requires an understanding of the principles of science, engineering, mathematics, and statistics, in addition to their own particular skills in air pollution control.

Personal Qualities

Air pollution control technicians must be in good health because air monitoring or sampling stations may be located on factory smoke stacks, water towers, or tall buildings. Such personnel must enjoy working out-of-doors, sometimes in inclement weather. Technicians must be willing to travel over a large area and often visit inner city slums and dirty factory towns. Technicians must be capable of carefully following directions from their superiors and communicating these directions to the skilled workers. Technicians must be tactful and courteous in answering questions and explaining regulations to the general public and to representatives of industries which are in violation of pollution emission standards.

Position Titles and Typical Duties

Air Pollution Control Technician I is an aide position that requires secondary level training.

Air Pollution Control Technician II. Under supervision following general directions, installs, operates, modifies, maintains, and repairs a variety of equipment and instruments. He may assist professional staff in special studies and in training lower level staff.

Examples of duties: Installs, operates, calibrates, modifies, maintains, and repairs air sampling equipment; conducts stack sampling activities and gathers data for source and emission inventories; conducts standardized analyses of air pollutants; records, tabulates, charts, and graphs data obtained from air sampling equipment, meteorological equipment, and laboratory analyses; assists in the placement of air sampling and meteorological equipment; assists higher-level staff conducting the more complex tests, measurements, and analyses; prepares oral and written reports of activities; provides technical assistance to lower-level employees; maintains an effective relationship with representatives of public and private agencies and organizations; may attend air pollution control hearings to present data and may be called as a witness in court cases.

Air Pollution Control Technician III. Under general supervision, with technical latitude, performs a broad range of technical duties of varying complexity in laboratory, shop, and field. This technician assists professional staff conducting special studies and leads and trains lower-level employees.

Examples of duties: Performs complex installations, operations, calibration, maintenance, and repair of air sampling equipment; performs complex tests, measurements, and analyses of air pollutants using standardized procedures; sites and places air sampling and meteorological instruments and equipment as directed; works independently on specialized assignments; prepares oral and written reports of activities and makes recommendations; assists professional staff conducting special studies; attends air pollution control hearings, presents evidence and data, and testifies as a witness in court cases; maintains and promotes effective personal relationships with associates and other public and private individuals; operates, is responsible for the daily maintenance of, and initiates requests for repair and maintenance of vehicles, instruments, and equipment; assists in training lower-level employees and other personnel.

Air Pollution Control Inspector II. Under supervision following general technical directions, performs field surveillance, facility and equipment inspection, and complaint investigation. The technician may assist professional staff conducting special studies. He may supervise and assist in the training of lower-level staff.

Examples of duties: Performs field surveillance of air pollution and documents the sources, quantity, and density of air pollution; performs facility and equipment inspection, noting level of operational effectiveness of air pollution control devices, recording observations and data, and reporting on inspection findings; investigates complaints through observing air pollution conditions, interviewing complaints, and owners and operators of allegedly-polluting equipment and facilities, and inspecting equipment and facility operations; develops detailed reports of complaint investigations together with recommendations as to corrective actions needed; prepares oral and written reports of activities; provides assistance to and makes work assignments to lower-level employees; maintains an effective relationship with representatives of public

and private agencies and organizations; may attend air pollution control hearings to present data and may be called as a witness in court cases; may work independently on specialized assignments.

Air Pollution Control Inspector III. Under general supervision, with technical latitude, performs field surveillance; facility and equipment inspection, and complaint investigation. The technician assists professional staff conducting special studies. He supervises and trains lower-level staff.

Examples of duties: performs field surveillance, facility and equipment inspection, and complaint investigation; works independently on specialized assignments; develops and presents recommendations as to new or different air pollution control processes and procedures; maintains files on daily activities including records of surveillances, investigations, and inspections; attends air pollution control hearings, presents evidence and data, and testifies as a witness in court cases; assists in the training of lower-level employees and other personnel; maintains and promotes effective personal relationships with public and private officials, agencies, and organizations; discusses air pollution - its causes, impact, and control - with public and private officials, agencies, and organizations in the course of field activities; may make recommendations regarding new and additional air pollution control equipment.

Industrial Air Pollution Control Technician. Under supervision, following general directions, installs, operates, calibrates, modifies, maintains, and repairs a variety of equipment and instruments used for air pollution control in an industrial installation. The technician may supervise or train lower-level technicians and skilled workers.

Examples of duties: Operates, calibrates, modifies, maintains, and repairs air pollution control equipment, such as electrical precipitators, cloth filter bags, fume burners, settling chambers, absorbers, and adsorbers, conducts stack sampling activities and gathers data for source and emission inventories; performs standardized analyses of air pollutants; records, tabulates, charts, and graphs data obtained from air sampling equipment and laboratory analyses, assist industrial plant engineers designing or modifying air pollution abatement equipment; assist industrial plant engineers reviewing and evaluating engineering proposals and drawings for new and modified industrial processes and facilities as actual or potential sources of air pollution; assist higher-level staff conducting the more complex tests, measurements, and analyses, prepares oral and written reports of activities; provides technical assistance to and may supervise work of lower-level employees; maintains an effective relationship with representatives of public and private agencies and organizations; may work independently on specialized assignments; may attend air pollution control hearings to present data and may be called as a witness in court cases.

TYPES OF EMPLOYERS

Air pollution control technicians may be employed by the large public agencies of the Federal government. Large numbers of these technicians are employed by the various divisions of the Environmental Protection Agency (EPA). Smaller numbers of these technicians are expected to be needed by the Public Health Service of the U.S. Department of Health, Education, and Welfare, and the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. Some permanent air pollution control technician positions in Federal agencies are in the classified civil service. The U.S. Civil Service Commission is currently developing position classification standards for additional air pollution control technician positions. For classified civil service positions, the U.S. Civil Service Commission gives entrance examinations each year. Advancement is based on ability.

Air pollution control technicians may find employment at the state level with the Department of Environmental Protection, Department of Environmental Resources, or Department of Health. Some state positions are classified civil service posts and require a rating on a competitive entrance examination.

Employment opportunities also exist with many county or municipal governments because the problem of air pollution from stationary and motor vehicle sources are associated with particular industries, electric power plant and high-density urban populations, and are therefore city- or community-oriented problems.

It is anticipated that there will be increasing employment opportunities for air pollution control technicians with industrial firms producing air pollution monitoring, sampling, and abatement equipment. Most industrial installations require air pollution control technicians to operate, maintain, and repair their air pollution control equipment.

Universities, colleges, and junior colleges which offer curricula in air science or air pollution control technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff.

Air pollution control technicians employed by the Federal government usually receive a starting salary of about $6,900 per year. Technicians who demonstrate the ability to do more responsible work are usually promoted to higher grade positions.

State, county, and municipal government positions generally pay slightly lower salaries than Federal government positions, while the salaries for industrial positions are comparable to the latter.

EMPLOYMENT OUTLOOK

Employment opportunities for air pollution control technicians are expected to be attractive and to increase for the foreseeable future. In recent years, technicians have been one of the fastest growing occupational groups and it is expected that this rapid growth will continue. One of the most comprehensive investigations attempting to estimate future air pollution technician needs is contained in a report titled "Preliminary Report of a State and Local Air Pollution Control Agency Manpower and Training Survey" conducted in April, 1971, by the U.S. Environmental Protection Agency. Twenty-nine percent of the filled positions in April, 1971, were Technician I - III and Inspector I - III.

An earlier report, titled "Manpower and Training Needs for Air Pollution Control" provides some data on employment needs for technicians in industry. This report was directed to the President and Congress by the Secretary of the Department of Health, Education, and Welfare in June, 1970. The survey estimated an increase from approximately 1,656 technicians in 1969 to 6,344 in 1974, an increase ratio of over 3.8. Significantly, the industries surveyed expressed no concern over the future supply of engineers and scientists. They were concerned, however, over what they saw as an increasingly pressing shortage of technicians. The necessity of providing the nation with an adequate supply of clean air for an increasingly urbanized and industrialized society on a static land area should insure a bright future for air pollution control technicians.

SUGGESTED AIR POLLUTION TECHNOLOGY CURRICULUM

General Program Considerations

The objective of the total program is to produce competent air pollution technicians. The technician must be capable of working and communicating directly with engineers, scientists, and other personnel; of satisfactorily performing work for his employer; and of growing into positions of increasing responsibility. In addition, the graduate technician should have a beginning basis for becoming an active, well-informed member of society.

A program which, when mastered, will produce the type of graduate described above must be carefully designed. Each course must be planned to help the student develop knowledge and skill in its particular area and be directly integrated into the program. The sequence of courses, each of which is specially constructed, contributes toward the final objective of producing a competent technician. If close correlation of courses making up the program is not maintained, the program will not enable the student to obtain an understanding at the depth required of modern air pollution control technicians.

The technical content of the program is intended to supply a wide educational background in the diverse areas of applied air pollution technology. In the first year, the student should acquire an understanding of the history of air pollution, and social,

economic, health, and technical implications. In addition to basic air sampling methods and analysis techniques, he should also gain insight into problem solving through studies in technical mathematics, physics, and chemistry.

The second year provides training at a higher level, including air pollution instrumentation, fundamentals of meteorology and advanced air sampling and analysis techniques. During this period, the student also receives instruction in the basic problems of wastewater treatment or solid waste disposal.

Technician education programs develop highly specialized persons who must be able to perform many tasks requiring special skills and who must appreciate the professional in education, attitude, and competence. Such programs provide for rigorous study of scientific principles and supporting mathematics and for intensive laboratory and field practice oriented to instruction. Programs must provide students with opportunities to gain (1) knowledge of applied scientific principles and of equipment, industrial and other energy processes, techniques, materials and instruments, and (2) the ability to communicate with engineers and scientists, and to serve as delegates or assistants to such persons. Although some technical and comprehensive high schools provide for technical and related vocational education, intensive programs such as described herein are more generally suited for two years of post-high school study.

Some indication of the special nature of engineering technician programs can be obtained from an analysis of what technicians must know, what special abilities the must possess and what they must be able to do in their daily work. Technicians must have the following special abilities:

1. Proficiency in the use of the disciplined and objective scientific method in practical application of the basic principles and laws of physics and chemistry and/or the biological sciences as they constitute the scientific base for the individual's field of technology.
2. Facility with mathematics: ability to use algebra and trigonometry as tools to develop, to define, or to quantify scientific phenomena or principles; and, when needed, an understanding of, though not necessarily facility with, higher mathematics through analytical geometry, calculus, and differential equations, according to the requirements of the technology.
3. A thorough understanding of and facility in the use of the materials, processes, procedures, and equipment commonly used in the technology.
4. An extensive knowledge of a field of specialization, with an understanding of the underlying physical or biological sciences and their application to the engineering health, or industrial processing or research activities that distinguish the technology of the field. The degree of competency and the depth of understanding should be sufficient to enable the individual to establish rapport with the engineers, scientists, managers, or researches with whom he works, and to enable him to perform a variety of detailed scientific or technical work using general procedures or instructions but requiring individual judgment, initiative, and resourcefulness in the use of techniques, handbook information, and recorded scientific data.
5. Communication skills that includes the ability to record, analyze, interpret, and transmit facts and ideas orally, graphically, and in writing with objectivity.[1]

A 2-year program to educate air pollution technicians must concentrate on primary or fundamental needs if it is to prepare students for responsible positions in modern technology. It must be realistic and pragmatic. The program suggested in this bulletin has been designed to provide maximum technical instruction in the time that is scheduled.

To those who are not familiar with this type of educational service (or with the goals and interests of students who elect it), the technical program often appears to be inordinately rigid and restrictive. While modifications may be necessary in certain individual institutions, the basic structure and content of this program should be maintained.

The specialized technical courses in the program are laboratory and field oriented. They provide time for the application of the scientific principles concurrently being taught in the courses in physics, chemistry and mathematics. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms, a principle that will be illustrated at several points. General education courses constitute a small part of the total program. It has been found that students who enter a technical program do so because of the depth of specialization that the program provides. Experience shows that many students who elect this type of program bring to it a background of general study.

Curriculum Outline

COURSES

First Semester
- Atmospheric Pollution
- Air Pollution Sampling and Analysis I
- Mathematics I
- Chemistry I
- Communication Skills

Second Semester
- Air Pollution Sampling and Analysis II
- Mathematics II
- Chemistry II
- Physics I
- Technical Reporting

Work Experience
- On-the-Job Work Experience in Air Pollution Control Technology: 10-16 weeks duration at 40 hours per week, usually during the summer months.

Third Semester
- Sources of Air Pollution
- Air Pollution Instrumentation
- Physics II
- Biology

Fourth Semester
- Meteorology
- Air Pollution Control
- Air Pollution Sampling and Analysis III
- Introduction to Wastewater Technology*
- (Optional Alternate Course: Principles of Solid Waste Management)
- Industrial Organizations, Institutions, and Government

Final Extended Field Trip
- Regional Air Pollution Control Practices: Three weeks of concentrated field observation at the close of the second year, at 40 hours per week

BRIEF DESCRIPTION OF COURSES

First Semester

Atmospheric Pollution
- As an introduction to the air pollution problem, this course considers the classification of pollutants, and their effects on man, plants and materials. Legal aspects of pollution control administration are also studied.

Air Pollution Sampling and Analysis I
- Basic air pollution sampling and analysis procedures with emphasis on ambient testing are studied. Dustfall, suspended

[1] Adapted from *Criteria for Technician Education - A Suggested Guide*. OE-80056, Washington, DC: U.S. Government Printing Office, 1968, page 3.

*Alternate Course:
Principles of Solid Waste Management – The origin and classification of solid wastes are studied in this course. Also considered are methods of collection, disposal, and management of solid waste programs.

particulates, oxides of sulfur, hydrocarbons, and other contaminants are considered in detail.

Mathematics I

This introductory course stresses application of the basic concepts of logic, sets, algebra, probability, analytic geometry, and trigonometry. Attention is given to the construction and analysis of tables, flow diagrams, and graphs.

Chemistry I

Selected fundamental concepts of chemistry and their practical application to the origin and control of air pollutants are studied in the first chemistry course. Experimental work stresses safety and accuracy in measurements and other laboratory techniques required of the air pollution technologist. Lecture topics include the structure and properties of matter, periodic classification of the elements, chemical bonding, elementary stoichiometry, equilibria, solutions and colloids.

Communications Skills

This course is designed to increase competence in reading, writing, speaking, and understanding oral instructions.

Second Semester

Air Pollution Sampling and Analysis II

This course concludes the study of ambient testing methods, and serves as an introduction to the basic methods of source sampling, including measurement and calculation of gas flow rate, humidity and psychrometry, ideal gas laws and their applications.

Mathematics II

The second math course is an extension of the concepts presented in Mathematics I, supplemented with an introduction to differential calculus and a brief survey of basic computer programming. Statistical analysis and treatment of data are also introduced.

Chemistry II

The final course in this sequence continues the study of descriptive chemistry and its application to the origin and control of air pollutants. Experimental work includes a variety of analytical techniques. Lecture topics include the chemistry of the atmosphere, typical properties and reactions of the element families, corrosion, nuclear chemistry, organic and biological chemistry.

Physics I

The basic principles of mechanical and thermal physics and their applications are considered here. Laboratory exercises stress applications to actual situations.

Technical Reporting

A study of effective ways of presenting information, with emphasis on the use of graphs, drawings, sketches, and outlines for various types of oral presentations and written reports.

Work Experience

On-the-Job Work Experience in Air Pollution Control Technology

The student is given an introduction to the various aspects of air pollution control technology through employment with an air pollution control organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of the air pollution control principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The air pollution control technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Sources of Air Pollution

A study of general and industrial processes which are actual or potential contributors to air pollution. Attention is focused on agriculture, transportation, industrial manufacturing and processing, and solid waste disposal. Source emission inventories are also studied.

Air Pollution Instrumentation

A study of the application of pneumatic, electronic, mechanical and chemical systems to the measurement of air pollutants. Accuracy of measurements, proper use of instruments, and calibration techniques are also considered.

Physics II

Electricity and magnetism, electronic instrumentation and work, energy and power. Principles stressed in lectures are reinforced in laboratory exercises designed to provide practical applications.

Biology

This course is concerned with basic concepts of environmental biology. Such concepts as energy flow, ecological niche, environmental resistance and various factors contributing to the upset of such balance are considered. Also studied are the various measures needed to restore the balance in the ecosystem.

Fourth Semester

Meteorology

Fundamental meteorological measurements and laws governing the atmospheric variables are presented. An introduction to solar radiation, adiabatic processes and stability, and weather analysis and forecasting. Diffusion from a continuous source is discussed in detail.

Air Pollution Control

Equipment and methods for the control of airborne pollution are studied. Specific topics include process and system control, centrifugal force and gravity methods, filtration, electrostatis precipitation, scrubbing, absorption, and combustion.

Air Pollution Sampling and Analysis III

This course is a continuation of source sampling methods. Isokinetic sampling, gas metering, absorption trains, impingers, and analytical procedures are studied.

Introduction to Wastewater Technology*

An introduction to the basic concepts of wastewater sources, treatment, and effects of treated and untreated wastewater on receiving bodies of water. Methods of disposal of treated wastewater on land surfaces will also be discussed.

Industrial Organizations, Institutions and Government

A study of the roles of labor and management in development of American industry. Analysis is made of forces affecting labor supply, employment, and industrial relations in a democratic system of government.

Final Extended Field Trip

Regional Air Pollution Practices

A 3-week field trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current air pollution control practices in his region. This field observation supplements the on-the-job training experience of the previous summer and permits him to observe air pollution control practices, instrumentation, and equipment which he has studied but may not have seen in operation.

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*Alternate Course:

Principles of Solid Waste Management – The origin and classification of solid wastes are studied in this course. Also considered are methods of collection, disposal, and management of solid waste programs.

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LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

Air Pollution Control Association
4400 Fifth Avenue
Pittsburgh, PA 15213

American Association for the Advancement of Science
1515 Massachusetts Avenue, N.W.
Washington, DC 20005

American Chemical Society
1155 Sixteenth Street, N.W.
Washington, DC 20036

American Meteorological Society
45 Beacon Street
Boston, MA 20108

Water Pollution Control Federation
3900 Wisconsin Avenue, N.W.
Washington, DC 20016

Chapter 3

FOREST AND RANGELAND TECHNOLOGIES

DEFINITION

A forest is a biological community dominated by trees and other woody vegetation. The forest consists of an assemblage of plants and animals living in a biotic association. A forest community exists in a physical environment composed of the atmosphere surrounding the aerial portions and the soil containing the subterranean portions.

Rangeland is defined as land on which the plant community is composed principally of native grass, forbs, and shrubs valuable for forage in sufficient quantity to enable grazing use. Such lands include the natural grasslands, savannahs, and certain types of woodland and chaparral useful for grazing.

SCOPE

Thirty-three percent of the land area of the United States is classified as forest and 28 percent consists of rangeland. The remaining land area is classified as follows (in percent): cropland, 20; miscellaneous (marshes, sand dunes, bare rock, desert), 12; special uses (park, wilderness areas), 5; urban development (cities, highways, railroads, airports, etc.), 2.

ENVIRONMENTAL SIGNIFICANCE

Forests and rangelands stabilize soil against erosion, provide protection for stream watersheds, provide forage for livestock, and food and cover for wildlife. Recreational uses of forests and rangelands include camping, picnicking, hiking, horseback riding, skiing, and snowmobiling. In addition, forests provide the wood products for the national economy.

Forests and rangelands contribute significantly to the environmental maintenance of the earth. Such lands are important in the global cycling of carbon dioxide and the terrestrial heat budget. Globally, the energy used to vaporize water from the surface of plants is about 10 percent of the solar energy reaching the land. Forests account for well over half of all transpiration. This form of evaporative cooling has a considerable influence upon regional climate, one that extends well beyond the immediate vicinity of the trees. The cooling effect of a warm, moist forest moderates summer temperatures in temperate latitudes. The photosynthetic activities of plant life replenish the oxygen supply of the atmosphere.

TECHNICAL POSITION REQUIREMENTS

Recent technological advances in the development, maintenance, regulation, and protection of forest and rangeland resources have created a serious shortage of highly trained forest and range technicians. These personnel are needed to assist professional foresters and range scientists in managing forests and rangelands. Forests and rangelands are managed for multiple-use objectives: water, forage, wildlife, and recreation. Forests must also provide a sustained yield of timber, pulpwood, and other products for forest industries. Some forests and rangelands are maintained in the wilderness state for aesthetic enjoyment, recreation, and ecological studies. More intensive management of forest and rangeland resources will be necessary to provide an adequate amount of these multiple-use objectives for an expanding population.

It has been widely recognized that forestry and range management always have required and probably will continue to require a large amount of technical work in the area between the skilled workman and the professional forester and range scientist. This technical work has been done by professional foresters, range scientists, students working toward professional degrees, and other persons with or without formal training but with practical woods or rangeland experience and on-the-job training.

The forest technician works under the general supervision of the professional forester or forest scientist. The Society of American Foresters defines a forest technician as follows:

> The forest technician is a person competent to occupy a responsible position in the line of authority between the skilled forest worker and the professional forester. He may direct the activities of the former under the supervision of the latter and must apply in a responsible manner proven techniques which are recognized as being professionally sound. The techniques employed demand acquired experience and knowledge of forestry, combined with the ability to work out the details of a task in the light of well established practice. The forest technician differs from the semi-skilled worker (aide) in his knowledge of forestry theory and methods and from the forester in his more limited or specialized background and in his use of technical skills in support of forestry activities. The senior (advanced) forest technician occupies the area between the skilled forest worker and the forester at the end of the spectrum closest to the professional forester. The forest technician requires an education and training sufficient to enable him to understand the reasons for, and the purposes of, the operation for which he is responsible. He should understand technical terms and appreciate the professional point of view. The forest technician does not need either the depth or extent of scientific understanding required of a forester but he does need a practical working knowledge of the same subject matter.

A definition of a rangeland technician is not available from the literature but presumably such personnel are similar to forest technicians with technical knowledge of rangeland management. Many rangeland technicians employed at present were originally educated as forest technicians. In recent U.S. Forest Service employment brochures, the job title of range technician is included with that of forest technician.

Competencies Required

Forest and rangeland technicians must be capable of working and communicating with professional foresters and range scientists as well as the skilled workers whom the technicians must supervise. Some forest and rangeland technicians perform manipulative tasks while others supervise the application of such skills. Most do both. Their work is distinguished from that of the skilled worker primarily in that it is less repetitive, involves more objective analysis and problem solving, and requires an understanding of the principles of science, engineering, mathematics, and statistics in addition to their own particular skills in forestry and rangeland management.

Personal Qualities

Forest and rangeland technicians must be in good health because many forests and rangelands are located in rugged mountains or arid semi-desert areas. Such people must enjoy working out-of-doors, sometimes in inclement weather. Technicians must be capable of carefully following directions from their superiors and communicating these directions to the skilled workers. Technicians must be

tactful and courteous in answering questions and explaining regulations to forest and rangeland visitors.

POSITION TITLES AND TYPICAL DUTIES

Forest and Rangeland Technology

Fire Control Technician. Surveys forest and rangeland for hazardous accumulations of dry vegetation that pose a high fire risk; supervise crews engaged in reducing fire risk by disposal of slash and brush by controlled burning or other methods. Supervises fire suppression crews in extinguishing forest or rangeland fires. Keeps inventory of fire fighting equipment and orders new equipment as required.

Pest Control Technician. Supervises crews engaged in survey and detection operations to determine the presence and extent of noxious insects, weeds, and plant diseases in forests and rangelands. Supervises control operation to destroy or reduce infestations of noxious organisms.

Research Technician. Works with foresters, range scientists, or scientists in related fields (entomologists, pathologists, ecologists, geneticists, etc.). Aids the professionals in developing new methods and operations and in conducting experiments aimed at developing, maintaining, and protecting forests and rangelands.

Forest Technology

Forest Nursery Technician. Employed as a forest nursery manager or forest nursery management assistant. Supervises crews of skilled workers in planting, mulching, lifting, packaging, and shipping forest tree seedlings. Such personnel are responsible for protecting the forest tree seedlings in the nursery from damage by drought, insects, disease, and wildlife.

Forest Management Technician. Supervises crews of skilled workers engaged in timber stand improvement activities. Such activities include pruning, thinning, and salvage operations. Forest management technicians supervise the marking of timber sale boundaries and timber marking for cutting operations.

Engineering and Survey Technician. Works with forest engineers to survey and establish boundaries of forest tracts. Inspects proposed location of logging roads to ensure adequate protection of soil, water-shed, and trees in the residual stand.

Rangeland Technology

Range Technician. Supervises skilled workers engaged in range manipulation through control of undesirable plants or animals, seeding, fertilizing, and other techniques. Supervises operations to improve wildlife habitat, and maintain watersheds. Conducts area surveys to determine forage plant densities, livestock densities, and intensities of recreational use on rangeland..

TYPES OF EMPLOYERS

Forest Technology

Employment opportunities for forest technicians exist in federal, state, and local government agencies, in educational institutions, and in private organizations and industries.

Forest technicians may be employed by the large public agencies of the Federal government. Large numbers of these technicians are employed by the Forest Service of the U.S. Department of Agriculture. Other Federal agencies employing forest technicians are the Bureau of Land Management, Bureau of Indian Affairs, National Park Service, and Fish and Wildlife Service of the U.S. Department of the Interior. A few positions exist with the Bureau of Outdoor Recreation, U.S. Department of Commerce, and Tennessee Valley Authority. Most permanent paraprofessional positions with Federal agencies are in the classified civil service. The U.S. Civil Service Commission gives entrance examinations each year. Advancement is based on ability.

Forest technicians may find employment at the state level with such agencies as the Department of Agriculture, Department of Environmental Resources, or Department of Fish and Game. State positions are usually classified civil service posts and require a rating on a competitive entrance examination.

Employment opportunities also exist with many county or city governments which own forests that are managed for park or watershed protection purposes.

Universities, colleges, and junior colleges which offer curricula in forestry or forest technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as research aid or technical assistants.

Many employment opportunities for forest technicians are found with pulp and paper companies and the lumbering, logging, and milling companies.

Forest technicians employed by the Federal government usually receive a starting salary of $6,900 per year. Technicians who demonstrate the ability to do more responsible work will be promoted to higher grade positions. Positions with private and industrial organizations are generally comparable in salary with Federal government positions, while academic and state and local government positions generally pay slightly lower salaries.

Rangeland Technology

Opportunities for employment for rangeland technicians exist in Federal, state, and local government agencies, in educational institutions, and in private organizations and industries.

Rangeland technicians may be employed by the large public agencies of the Federal government. Federal agencies which employ rangeland technicians include the Forest Service of the U.S. Department of Agriculture and the following organizations in the U.S. Department of the Interior: Bureau of Land Management, Bureau of Indian Affairs, National Park Service, Fish and Wildlife Service, and Bureau of Outdoor Recreation. Most permanent paraprofessional positions with Federal agencies are in the classified civil service. The U.S. Civil Service Commission gives entrance examinations each year. Advancement is based on ability.

Rangeland technicians may find employment at the state level with the Department of Agriculture, Department of Environmental Resources, or Department of Fish and Game. State positions are usually classified civil service posts and require a rating on a competitive entrance examination.

Employment opportunities also exist with county or city governments which own rangelands that are managed for grazing, wildlife, or watershed protection purposes.

Universities, colleges, and junior colleges which offer curricula in range science or range technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as research aid or technical assistant.

A few private organizations, such as stockmens associations, employ rangeland technicians.

Rangeland technicians employed by the Federal government usually receive a starting salary of $6,900 per year. Technicians who demonstrate the ability to do more responsible work will be promoted to higher grade positions. Academic and state and local government positions generally pay slightly lower salaries.

EMPLOYMENT OUTLOOK

Employment opportunities for forest and rangeland technicians are expected to increase moderately for the forseeable future. Assuming a ratio of two technicians to one professional and an intensity of forest resource management calling for one professional forester for every 20,000 acres of commercial forest lands and one professional forester for every 40,000 acres of non-commercial forest lands, the 12,000 forest technicians employed in 1966-67 will increase to 24,000 by 1980. Projections of the future demand for rangeland technicians are not available. The necessity of providing the nation with a sustained yield of wood products from forests and of managing forests and rangelands to provide water, forage, wildlife, and recreation for an increasing population on a static land area should ensure continuing employment opportunities for forest and rangeland technicians.

SUGGESTED TECHNICAL CURRICULA

General Program Considerations

The objective of the total program of formal education for forest and rangeland technicians is to produce a competent individual capable of entering any of several closely related positions.

Because forest and rangeland technicians are employed in numerous and often specialized situations, the adequately trained technician must have attained the following abilities, scientific knowledge, and technical skills:

1. Facility with mathematics: The ability to use algebra and basic trigonometry as tools in the development of ideas that make use of scientific principles related to forests and rangelands. A basic knowledge of statistical methods is required.
2. Proficiency in the application of scientific principles, including the basic concepts and laws of physics and biology which are pertinent to forest and rangeland technology.
3. An understanding of the materials, processes, and techniques commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the scientific activities that distinguish the technology of the field, such as prism sampling, log scaling, livestock census methods, and insect and disease survey methods.
5. Communication skills that includes the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.[1]

The technical program has the usually recognizable five subject matter divisions, namely: (1) specialized courses in the technology; (2) auxiliary or supporting technical courses (such as technical report writing and forest technology seminars); (3) mathematics courses; (4) science courses (such as soils and botany courses); and (5) general education courses. The technical subjects provide application of scientific and forest and rangeland principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms. General education courses constitute a relatively small part of the total program.

Curriculum Outline in Forest Technology

COURSES

First Semester
- Elementary Forest and Range Surveying
- Communication Skills
- Applied Mathematics
- Botany
- Dendrology
- Forestry Orientation Seminar

Second Semester
- Technical Reporting
- Elementary Forest Measurements
- Applied Silviculture
- Forest Soils
- Technical Drawing
- Elementary Business Management

Work Experience
- On-the-Job Work Experience in the Forestry Field: Work Program, 10-16 weeks duration at 40 hours per week, usually during the summer months.

Third Semester
- Personnel Management
- Forest Business Methods
- Timber Harvesting
- Advanced Forest and Range Surveying
- Outdoor Recreation
- Wildlife Ecology

Fourth Semester
- Elements of Social Science
- Forest Products Utilization
- Forest and Range Protection
- Advanced Forest Measurements
- Forest Photo-Interpretation

Final Extended Field Trip
- Regional Forest Practices and Utilization - Three weeks of concentrated field observation at the close of the second year, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Forest Survey
: An elementary course in the theory and basic principles of plane surveying emphasizing practical laboratory and field application in forest and range surveying.

Communication Skills
: A program designed to develop greater competence in reading, writing, speaking, and listening.

Applied Mathematics
: A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they related to the application of right triangles, indentities, and equations in forest surveying.

Botany
: An elementary classroom and laboratory study of the forms and living processes of seed plants. It includes a study of the structure and function of roots, stems, leaves, flowers, and seeds. Metabolic processes and responses to stimuli, and a study of plant heredity are included.

Dendrology
: An elementary study of trees; their habitats and principal botanical features, forms, functions, and ecological relationships. The major commercially important forest trees of the region are examined in class and through extensive field and laboratory studies. Scientific classification of plants and identification of regional flora is emphasized. The content of this course is closely coordinated with *Botany*.

Forestry Orientation Seminar
: A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and resource personnel visits. Consideration is given to the broad historical development of forestry in Europe and the United States, to forest terminology, and to forest policy at various levels. Current events in forest management activities are discussed.

Forest organizations at the private and various governmental levels are examined. A survey of the various kinds of occupations is made, and the demands and opportunities are stressed. Outside study is required. Forestry programs, education, research, and future trends are analyzed. Representative guest lecturers from industry and government are invited to participate.

Second Semester

Technical Reporting
: A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and form are emphasized.

Elementary Forest Measurements
: A classroom and field study of the basic principles and skills required for timber measurements. Direct and indirect systems of measurement and volume computation, forest

[1] Adapted from *Criteria for Technician Education – A Suggested Guide*. OE-80056, Washington, DC: U.S. Government Printing Office, 1968, page 3.

type mapping, and graphic reporting are studied and practiced.

Applied Silviculture

An introduction to the artificial reforestation, natural forestation, and silvicultural practices in the United States. Improvements of forest stands through the basic silvicultural practices of weeding, thinning, pruning, and various cutting techniques and the marking of stands prior to logging operations are studied. Laboratory and field exercises are emphasized.

Forest Soils

An elementary study of the basic principles of soils, soil management, and fertility. The geographical and geological formation and classification of soils are examined; and soil organisms, chemicals, conservation, and management are studied. The physical and chemical properties of soil are explored in laboratory exercises.

Technical Drawing

A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce clear, legible, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting and forest management activities.

Elementary Business Management

A course which introduces the student to the fundamental principles and techniques of organization, management, and operation of a successful small business enterprise. It includes a study of the principles of inventory, accounting, selling, and other phases of management. Discussions of forest enterprises are presented by guest speakers.

Work Experience

On-the-Job Work Experience in the Forestry Field

The student is given an introduction to the various fields of forest technology through employment with a forestry concern or organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the forestry principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The forestry technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Personnel Management

An introductory course in the basic principles of organization for effective personnel management. Selecting and training employees, planning and assigning work, human relations involving motivation, maintaining morale, and special problems of forest technicians are studied. This course is coordinated with courses involving field operations to provide exercises in which students direct the efforts of their fellow students.

Forest Business Methods

An introduction to small business operation, including a study of simple bookkeeping, compound interest, discounts, taxation, capital gains, simple contracts, timber valuation, and recording of timber cutting. State forest laws as they relate to the service and operations required in the conduct of a small forest business enterprise are examined.

Timber Harvesting

This course includes a study of regional forest harvesting practices, crew organization, planning the harvesting, skidding, loading, transportation methods, operational safety, and cost analysis. Practical experience is emphasized in the laboratory and field exercises.

Advanced Forest and Range Surveying

A continuation of the study of forest and range surveying providing a greater depth in the study of precision surveying techniques, and the use of precision instruments for plane surveying. Field practice is provided in precision taping, differential and profile leveling, measuring cross sections and making plane table, transit, stadia, and transit tape surveys.

Outdoor Recreation

A field oriented study of the use of forest resources for recreation. The course is business oriented and includes a study of the demand for outdoor recreation, kinds of recreational enterprises, use of camp grounds and sport areas, and the selecting, developing, managing, and merchandising of recreational enterprises.

Wildlife Ecology

An introductory study of the principles of wildlife ecology and the conservation of wildlife resources, with emphasis on terrestrial communities. The field and laboratory experiences study wildlife management techniques and how the wildlife population may conflict with forest use.

Fourth Semester

Elements of Social Science

An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles, and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society generally.

Forest Products Utilization

A course which introduces the student to milling and subsequent utilization of forest products. The process of converting logs to lumber or other marketable products and by-products is studied. Air and kiln drying, lumber stacking, and yard layout are considered. Utilization of milling waste and the marketing of various forest products are studied. The laboratory and field work in this course includes field trips and practical application of the principles studied.

Forest and Range Protection

An elementary course in the protection of forests and rangelands from disease, insects, and fire. Special emphasis is placed on the identification of disease-causing organisms and harmful forest and rangeland insects, with less emphasis on methods employed in their control. The basic principles of forest and rangeland fire prevention, pre-suppression, detection, fire behavior, and the various methods, equipment, and crew organizations used in fire fighting are studied. The relative emphasis on diseases, insects, and fire factors is optional. Some institutions in some regions may choose to place over half of the course emphasis on protection of forests and rangelands from fire and to include special studies of man-originated fires.

Advanced Forest Measurements

A continuation of the study of forest measurements, including an examination of the current and newest techniques of forest and timber inventory. The principle of stratification in the design of cruises, and the consideration of volume tables and their use are studied. The course is laboratory and field oriented. Formal cruise reports are required in which each student reports his work and describes the types and methods of presentation of technical forest measurement data and reasons for their use. The field work also includes practical experience in preparing a cruise map, and the application of basic statistical knowledge to timber measurements.

Forest Photo-Interpretation

An introduction to the principles and practices of interpreting aerial forest photographs, with emphasis on forest

typing, mapping, road reconnaissance, and inventory techniques. The use of aerial photographs to obtain such photogrammetric data as location, direction, area, and timber volume based on photomensurational techniques is studied.

Final Extended Field Trip

Regional Forest Practices and Utilization

A three-week field trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand obersvation of the current forestry practices in his region. This field observation supplements the on-the-job training experience of the previous summer and permits the student to observe forestry practice, forest harvesting methods, and product utilization which he has studied but may not have seen in operation.

A few institutions offer a one-year curriculum in Forest Technology. Such curricula are very similar to the one outlined above but the subject matter is covered with less depth.

Curriculum Outline in Rangeland Technology

Institutions located in areas of the United States where rangelands are more prevalent than forests may find it desirable to initiate programs in Rangeland Technology. The suggested curriculum outline for institutions which elect to educate Rangeland Technicians is identical with that for Forest Technology, except for the course substitutions listed and described below.

COURSES

First Semester

Range Plant Identification (replaces Dendrology)

Rangeland Orientation Seminar (replaces Forestry Orientation Seminar)

Second Semester

Elementary Range Management (replaces Elementary Forest Management)

Applied Geology (replaces Applied Silviculture)

Rangeland Soils (replaces Forest Soils)

Introduction to Rangeland Ecology (replaces Elementary Business Management)

Work Experience

On-the-job Work Experience in the development, protection, maintenance, and regulation of rangelands: Work Program — 10-16 weeks duration at 40 hours per week, usually during the summer months.

Third Semester

Advanced Range Management (replaces Forest Business Methods)

Watershed Hydrology (replaces Timber Harvesting)

Fourth Semester

Techniques and Systems of Rangeland Management (replaces Forest Products Utilization)

Rangeland Animals (replaces Advanced Forest Measurements)

Rangeland Photo-interpretation (replaces Forest Photo-interpretation)

Final Extended Field Trip

Regional Rangeland Management Practices — Three weeks of concentrated field observation at the close of the second year, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Range Plant Identification (replaces Dendrology)

An elementary study of herbs, forbs, and grasses; their habitats, forms, functions, and principal botanical features. The species of herbs, forbs, and grasses which are important foods for wildlife and livestock are examined in class and through extensive field and laboratory studies. Scientific classification of plants and identification of regional flora is emphasized. The content of this course is closely coordinated with Botany.

Rangeland Orientation Seminar (replaces Forest Orientation Seminar)

A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and resource personnel visits. Consideration is given to the broad historical development of rangelands in the United States and in other parts of the world, to rangeland terminology, and the rangeland policy at various levels. Current events in rangeland management activities are discussed.

Rangeland management organization at the various governmental levels are examined. A survey of the various kinds of occupations is made and the demands and opportunities are stressed. Outside study is required. Rangeland programs, education, research, and future trends are analyzed. Representative guest lecturers from industry and government are invited to participate.

Second Semester

Elementary Range Management (replaces Elementary Forest Measurements)

History of use, influences of use on plant physiology and ecology; interrelationships and coordination of rangeland uses.

Applied Geology (replaces Applied Silviculture)

A survey of surface geologic processes: weathering sedimentation and sedimentary rocks, stream regimen, ground water, wind action, and glaciation.

Rangeland Soils (replaces Forest Soils)

An elementary study of the basic principles of rangeland soils, including management and fertility. The geographical and geological formation and classification of rangeland soils are examined. Soil organisms, chemicals, and conservation practices are studied. The physical and chemical properties of rangeland soils are explored in laboratory exercises.

Introduction to Rangeland Ecology (replaces Elementary Business Management)

Elementary principles and concepts pertaining to energy, nutrients, limiting factors, and organization in rangeland ecological systems; analysis of succession; application of ecological principles to rangeland resources. The content of this course is closely coordinated with Natural Resources Measurements.

Work Experience

On-the-Job Work Experience in A Phase of Rangeland Technology

The student is introduced to the development, protection, maintenance, and regulation of rangeland resources through employment with a rangelands management agency between his freshman and sophomore years. This experience is very important since it provides the student with the opportunity to practice and observe the application of some of the principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in later semesters. The rangeland technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Advanced Range Management (replaces Forest Business Methods)

Detailed study of case histories of rangeland mismanagement and subsequent rangeland improvement treatments with an evaluation of the effectiveness of the treatments.

Watershed Hydrology (replaces Timber Harvesting)

Application of fundamental principles to quantifying the basic hydrologic processes occurring on watersheds.

Fourth Semester

Techniques and Systems of Rangeland Management (replaces Forest Products Utilization)

Methods of manipulating populations of rangeland livestock and wildlife. Tolerances of rangeland plant species and communities to grazing. Techniques of salting, water management, fencing, rates of stocking, etc. Estimation of carrying capacity of different types of rangeland.

Rangeland Animals (replaces Advanced Forest Measurements)

Applied studies of grazing behavior, nutrition, reproduction, and ecology of rangeland livestock and wildlife.

Rangeland Photo-interpretation (replaces Forest Photo-interpretation)

An introduction to the principles and practices of interpreting aerial rangeland photographs, with emphasis on rangeland typing, mapping, road reconnaissance, and inventory techniques.

Regional Rangeland Management Practices

A three-week field trip to provide concentrated and varied field observation at the end of the fourth semester gives the student first-hand observation of the current rangeland management practices in his region. This field observation supplements the on-the-job training of the previous summer and permits the student to observe rangeland reclamation, the allocation of livestock grazing quotas, watershed protection, rangeland weed control, rangeland fire suppression, and other management practices which he has studied but may not have seen in operation.

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LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

American Forestry Association
1319 18th Street, N.W.
Washington, DC 20036

Society of American Foresters
Suite 300
1010 16th Street, N.W.
Washington, DC 20036

Society for Range Management
2120 South Birch Street
Denver, Colorado 80222

Society of Wood Science and Technology
College of Forestry
Colorado State University
Fort Collins, Colorado 80521

Chapter 4

MINERALS AND MINERAL FUELS TECHNOLOGY AND GEOLOGICAL TECHNOLOGY

DEFINITION

Minerals are inorganic compounds which are found in the earth's crust. Minerals are generally solid, naturally formed substances possessing definite physical properties and chemical compositions which are variable but are definitive enough to permit classification and expression as chemical formulae. Some organic compounds, such as coal, petroleum, and natural gas, which are not classified as minerals, are considered to be minerals for the purpose of this curriculum guide.

SCOPE

The planet earth is composed of minerals. Minerals are cosmopolitan in distribution in the earth's crust, the deeper layers of the earth, and on and under the ocean floor.

ENVIRONMENTAL SIGNIFICANCE

Minerals are an important contributing factor to man's physical environment. The mineral components of continental rock have been modified by physical, chemical, and biological forces over billions of years into the soil medium which is one of the most important life-supporting components of the biosphere. Metallic mineral ores, such as iron, copper, zinc, and nickel, provide the raw materials for a variety of industrial products. The fossil fuels (coal, petroleum, and natural gas) provide the vast energy resources required for industrial production, heating of residences and other buildings, and modern transportation systems.

The expanding world human population will require ever increasing amounts of energy from mineral fuels. The anticipated increase in the number of nuclear fuel power plants will necessitate the location and development of additional deposits of radioactive ores. The mining and industrial modification of minerals and mineral fuel resources cause serious air and water pollution problems. Public agencies at all governmental levels and industries will have to initiate long-term programs to develop effective methods of protecting the environment while securing the domestic, industrial, and military benefits of mineral and mineral fuel resources.

TECHNICAL POSITION REQUIREMENTS

Technicians who assist scientists and engineers engaged in the development, maintenance, regulation, and protection of mineral and mineral fuel resources generally work in one of two broad areas: (1) Mining Technology and (2) Geological Technology.

Mining technicians assist mining engineers, mine inspectors, and mine safety engineers to develop and extract mineral resources and provide safe working conditions for miners in compliance with Federal and state mine safety laws.

Geological technicians assist economic geologists, petroleum geologists, mineralogists, mining geologists and geological engineers to locate, delimit, evaluate, and develop mineral and mineral fuel resources.

Recent technological advances in the prospecting for and extraction of mineral fuels have created a serious shortage of highly trained technicians. The management of minerals and mineral fuels always has required and will continue to require a large amount of technical work between the skilled workman and the professional scientist, engineer, and administrator. This technical work has usually been accomplished in the past by baccalaureate-level technologists, students working toward professional degrees, and other persons with or without formal training but with practical experience in some aspect of minerals, fuels, and on-the-job training.

Mining technicians work under the general supervision of professional engineers while geological technicians are supervised by professional geologists and geological engineers. The technician is competent to occupy a responsible position in the line of authority between the skilled worker and the professional scientists or engineer. The technician often directs the activities of skilled workers. The minerals and mineral fuels technician differs from the skilled worker in his theoretical and applied knowledge of mineral and mineral fuel resources. He differs from the scientist and engineer in his more limited or specialized background and in his use of technical skills in support of minerals and mineral fuel resources management. The minerals and mineral fuels technician requires an education and training sufficient to enable him to understand the reasons for and the purposes of the operation for which he is responsible.

Many skilled paraprofessional personnel have been employed in minerals and mineral fuels resources for several years. However, the need for formally educated technicians in minerals and mineral fuels is a comparatively recent development. Technicians assist scientists and engineers in discovering new deposits of minerals, in efficient and safe mining of minerals and mineral fuels for domestic, industrial, and agricultural uses, and in protecting the unmined portion of the minerals and mineral fuels. Public concern for the quality of the environment has stimulated widespread effort by Federal and state governments to curb the pollution of air and water and the destruction of soil and vegetation by the mining and utilization of minerals and mineral fuels. Air and water pollution control equipment is being used in mining operations, and extensive programs to reclaim strip-mined lands are being carried out.

Competencies Required

Technicians who work with minerals and mineral fuels resources must be capable of working and communicating with professional scientists, engineers, and administrators as well as the skilled workers whom the technicians must supervise. Some technicians perform manipulative tasks while others supervise the application of such skills, but most do both. Their work is distinguished from that of the skilled worker primarily in that it is less repetitive, involves more objective analysis and problem solving, and requires an understanding of the principles of science, engineering, mathematics, and statistics, in addition to their own particular skills in mining technology or geological technology.

Personal Qualities

Minerals and mineral fuels technicians must be in good health. Conducting geological field surveys of surface rock formations in rugged terrain and obtaining samples from the deepest tunnels of a mine require considerable physical stamina. Such personnel must enjoy working out-of-doors, sometimes in inclement weather. Mining and geological operations must sometimes be conducted at

irregular hours or for long periods of time. Technicians must be capable of carefully following directions from their superiors and communicating these directions to the skilled workers.

POSITION TITLES AND TYPICAL DUTIES

Mining Technology

Mining Technician. Conducts surface and underground surveys at coal and ore mines to aid mining engineers in controlling direction and extent of mining. Obtains and compiles data necessary for driving and connecting underground mining passages. Computes volume of coal or ore in portions of mine, using survey notes. Surveys and calculates volume of material in dumps, spoil piles, or veins, and the amount of overburden to be removed. Drafts maps of mines workings. Inspects underground or open-pit mines to detect unsafe working conditions and violations of state and local mining regulations or contractual agreements. Looks for rotted or incorrectly placed timbers, dangerously placed or defective electrical and mechanical equipment, and improperly stored explosives. Tests air to detect toxic or explosive gas or dust, using safety lamp and methane detector. Observes mine activities to detect violations of Federal, state, and local mine safety regulations. Inspects mines to insure compliance with production rates and mining within specified limits. Prepares reports on mine operations and safety conditions.

Geological Technology

Geological Technician. Explores likely regions to discover valuable mineral deposits, using topographical maps, surveys, reports, and knowledge of geology and mineralogy. Examines outcrops, floats, and stream channels for mineral content. Drills, dynamites, or digs trenches or pits along rock formations or creek beds to obtain rock samples. Conducts quantitative and qualitative tests for mineral contents of rock samples. Collects data on rock formations, using electrical, magnetic, seismic, gravimetric, and radioactive instruments. Compiles and summarizes data for interpretation by geologists and geophysical engineers. Assists geologists in determining feasibility of staking and developing claim. Assist mining engineers in the development of mineral deposits by means of placer or hard rock mining. Interviews property holders and compiles data for adjustment of damage claims resulting from activities connected with prospecting, drilling, and production of oil and gas and laying of pipelines on private property. Investigates and assess damage to crops, fences, and other properties. Collects and prepares evidence to support contested damage claims in court.

TYPES OF EMPLOYERS

Mining Technology

Employment opportunities for mining technicians exist in Federal and state government agencies, in educational institutuions, and in private organizations and industries.

Mining technicians may be employed by the Bureau of Mines, U.S. Department of the Interior, as Federal Mine Inspectors. Federal Mine Inspectors may specialize in metal and nonmetal mines, coal mines, or coal mine electrical equipment. Most paraprofessional positions with Federal agencies are in the classified civil service. Advancement is usually based on ability.

State governments employ mining technicians in their Departments of Mining and Natural Resources. State positions are usually classified civil service posts which require a rating on a competitive entrance examination.

Universities, colleges, and junior colleges which offer curricula in mining engineering or mining technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff and may range in academic rank from research assistant to instructor.

A large number of mining industries involved in mining minerals and mineral fuels employ mining technicians to improve the efficiency and safety of their employees and physical plants. A few private mining consulting firms may employ mining technicians.

Geological Technology

Opportunities for employment for geological technicians exist in Federal and state government agencies, in educational institutions, and in private organizations and industries.

Geological technicians may be employed by the U.S. Geological Survey, U.S. Bureau of Mines, Coast and Geodetic Survey, and the U.S. Corps of Engineers. Most paraprofessional positions with Federal agencies are in the classified civil service. Advancement is usually based on ability.

State governments employ geological technicians in their Departments of Mining and Natural Resources. State positions are usually classified civil service posts which require a rating on a competitive entrance examination.

Universities, colleges, and junior colleges which offer curricula in geological science and engineering or geological technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff and may range in academic rank from research assistant to instructor.

Many technicians are needed by petroleum and mining companies for prospecting, development, and production of minerals and mineral fuels. Geological technicians may also find opportunities with railroads, sand and gravel companies, and the chemical, cement, and ceramic industries.

Mining and geological technicians employed by the Federal government usually receive a starting salary of about $6,000 per year. Positions with private and industrial organizations are generally comparable in salary with Federal government positions, while academic and state government positions usually pay slightly lower salaries than Federal government and industrial positions. Technicians who demonstrate the ability to do more responsible work are promoted to higher salaried positions.

EMPLOYMENT OUTLOOK

Employment opportunities for mining and geological technicians are expected to be attractive, and to increase for the forseeable future. In recent years, technicians have been one of the fastest growing occupational groups and it is expected that this rapid growth will continue.

The necessity of providing America with an adequate supply of minerals and mineral fuels for industrial production, building construction, and energy sources will continue to require the services of mining and geological technicians. The location, development, utilization, and conservation of mineral and mineral fuel resources are essential for the continued economic development and security of the nation.

SUGGESTED TECHNICAL CURRICULA

General Program Considerations

The objective of the total program of formal education for mineral and mineral fuel resources technicians is to produce competent individuals capable of entering any of several closely related positions within one of the mineral and mineral fuel resources areas: mining technology and geological technology.

Because mineral and mineral fuel resources technicians are employed in numerous and often specialized situations, the adequately trained technician must have attained the following abilities, scientific knowledge, and technical skills:

1. Facility with mathematics: The ability to use algebra and basic trigonometry as tools in the application of scientific principles related to problems in minerals and mineral fuels.
2. Proficiency in the application of scientific principles, including the basic concepts and laws of chemistry and physics which are pertinent to mineral and mineral fuel resources.
3. An understanding of the materials, processes, and techniques commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the scientific activities that distinguish the technology of the field, such as use of the Geiger counter to

locate radioactive mineral ore deposits and techniques of underground mine surveying.

5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.[1]

The technical program has the usually recognizable five subject matter divisions, namely:: (1) specialized courses in the technology; (2) auxiliary or supporting technical courses (such as technical report writing and mining technology orientation seminars); (3) mathematics courses; (4) science courses (such as physics and chemistry); and (5) general education courses. The technical subjects provide application of scientific and mineral and mineral fuel resources principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two semesters. General education courses constitute a relatively small part of the total program.

Curriculum Outline in Mining Technology

COURSES

First Semester
- Elementary Inorganic Chemistry
- Applied Mathematics
- Communication Skills
- Physical Geology
- Applied Physics
- Mining Technology Orientation Seminar

Second Semester
- Technical Reporting
- Technical Drawing
- Mineral Land and Mine Surveying
- Statics and Strength
- American Government Institutions

Work Experience
- On-the-Job Work Experience in Mining Technology: Work programs, 10-16 weeks at 40 hours per week, usually during the summer months.

Third Semester
- Mining and Safety Engineering
- Fundamentals of Industrial Engineering
- Coal Mining Technology
- Reclamation of Mined Lands
- Elements of Social Science

Fourth Semester
- Mine Management and Law
- Mine Design, Ventilation, and Drainage
- Preparation and Disposal
- Mining Equipment, Control, and Applications
- Personnel Management

Final Extended Field Trip
- Regional Mining Technology Practices: Three weeks of concentrated field observation at the close of the second year at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Inorganic Chemistry
A classroom and laboratory course in the theory and basic principles of inorganic chemistry. Special emphasis is placed on those portions of chemistry which are essential to the understanding of mineral composition.

Applied Mathematics
A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles, identities, and equations in surveying.

Communication Skills
A program designed to develop greater competence in reading, writing, speaking, and listening.

Physical Geology
Earth processes and their effects on the materials, structure, and morphology of the earth's crust. The laboratory includes the field observation and collection of rocks and minerals, identification of rocks and minerals, and the use of topographic maps.

Applied Physics
An elementary survey course covering the basic principles and concepts of mechanics, wave motion, sound, electricity, magnetism, heat, and optics.

Mining Technology Orientation Seminar
A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and lectures by mining industry personnel. Consideration is given to the broad historical development of mining operations in Europe and the United States, mining terminology, and mining resources management policy at various levels. Current events in mining technology are discussed. Mining resources organizations at the various government and industrial levels are examined. A survey of the various kinds of occupations is made and the demands and opportunities are stressed. Outside study is required. Mining resources development programs, education, research, and future trends are analyzed. Representative guest lecturers from industry and government are invited to participate.

Second Semester

Technical Reporting
A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Appropriate form, conciseness, and accuracy are emphasized.

Technical Drawing
A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce legible, clear, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting.

Mineral Land and Mine Surveying
Surveying theory and practice applied to mineral lands and mines. This field-oriented course includes traversing, leveling, mapping, shaft plumbing, and slope, room, and development surveying.

Statics and Strength
A classroom and laboratory course in applied engineering mechanics. The lectures cover the principles of statics and kinematics, behavior of materials under loads, stress-strain relationships, torsion, flexure, and bearing stresses. Laboratory practicums include studies of tension, compression, shear, impact, fatigue, and hardness of various materials.

Mining Mechanics
A laboratory course covering the operation, maintenance, and repair of mining machinery and equipment.

American Government Institutions
Organization and operation of governmental organizations at the national, state, and local levels and their responsibilities and activities which affect mining resources.

[1] Adapted from *Criteria for Technician Education–A Suggested Guide*. OE-80056, Washington, DC: U.S. Government Printing Office, 1968, page 3.

Work Experience

On-the-Job Work Experience in Mining Technology

The student is given an introduction to various areas of mining technology through employment with a mining resources organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the mining technology principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The mining technology faculty keeps close contact with the student and his employer. A highly structured program and regular reports by the student add depth to the work experience.

Third Semester

Mining and Safety Engineering

A basic survey course of exploration, evaluation, development, extraction, unit operations, cycling equipment, methods, and mineral economics as related to mining. Laws concerning mine safety are interpreted.

Fundamentals of Industrial Engineering

Basic concepts and applied uses of hydraulics and electronics in mining machinery and equipment.

Coal Mining Technology

Analysis of coal mining systems, integration of unit operations and mining methods for efficient mine production.

Reclamation of Mined Lands

A classroom and laboratory study covering the methods and equipment used to restore vegetative cover to strip-mined lands.

Elements of Social Science

An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles, and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society in general.

Fourth Semester

Mine Management and Law

Mining laws, both state and Federal, and means of implementation under practical mining situations. The problems of the individual in mine management in relation to environment, employer, union, and law.

Mine Design, Ventilation, and Drainage

A study of mine plant systems which includes methods of hauling, machinery requirements and selection, electrical and mechanical power transmission, drainage, ventilation, preparation, and waste disposal. This course is a system study and many of its parts will be studied in depth in other courses.

Preparation and Disposal

Basic chemistry of preparation, unit operations, flow sheets, and testing methods used in the preparation of coal. Also covered are refuse and methods of disposal with their ecological impact.

Mining Equipment, Control, and Applications

A survey course of modern mining equipment as applied to the extraction of coal and other minerals. The student's knowledge of electronics, mechanics, and hydraulics are integrated and applied toward developing an understanding of practical mining machines.

Personnel Management

An introductory course in the basic principles of organization for effective personnel management. Selecting and training employees, planning and assigning work, human relations involving motivation, maintaining morale, and special problems of mining technicians are studied.

Final Extended Field Trip

Regional Mining Technology Practices

A three-week field trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current mining practices in his region. This field observation supplements the on-the-job traing experience of the previous summer and permits the student to observe mining techniques, safety measures, and mined land reclamation operations which he has studied but may not have seen in operation.

Curriculum Outline in Geological Technology

COURSES

First Semester
- Elementary Inorganic Chemistry
- Applied Mathematics
- Communication Skills
- Land Forms of the World
- Physical Geology
- Geological Technology Orientation Seminars

Second Semester
- Technical Reporting
- Technical Drawing
- Mineral Land Surveying
- Applied Physics
- Economics of Resources
- American Government Institutions

Work Experience
- On-the-Job Work Experience in Geological Technology: Work programs, 10-16 weeks at 40 hours per week, usually during the summer months.

Third Semester
- Cartography
- Metallic and Non-Metallic Minerals
- Introduction to Coal, Gas, and Oil Geology
- Gem Minerals
- Physics of the Earth

Fourth Semester
- Aerial Photo-Interpretation
- Geophysical Surveying
- Geology of North America
- Geophysical Prospecting for Oil and Natural Gas
- Reclamation of Mined Lands

Final Extended Field Trip
- Regional Geological Technology Practices: Three weeks of concentrated field observation at the close of the second year at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Inorganic Chemistry

A classroom and laboratory course in the theory and basic principles of inorganic chemistry. Special emplasis is placed on those portions of chemistry which are essential to the understanding of mineral composition.

Applied Mathematics

A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles, identities, and equations in surveying.

Communications Skills

A program designed to develop greater competence in reading, writing, speaking, and listening.

Land Forms of the World

Distribution of the world's landform features and mineral resources; their characteristics, causes, and significance. The practicum includes correlated field trips and laboratory studies.

Physical Geology

Earth processes and their effects on the materials, structure, and morphology of the earth's crust. The laboratory includes the field observation and collection of rocks and minerals, identification of rocks and minerals, and the use of topographic maps.

Geological Technology Orientation Seminar

A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and lectures by geological science personnel. Consideration is given to the broad historical development of the geological sciences in Europe and the United States, geological terminology, and geological resources policy at various levels. Current events in geological technology are discussed. Geological resources organizations at the various governmental and industrial levels are examined. A survey of the various kinds of occupations is made and the demands and opportunities are stressed. Outside study is required. Geological resources development programs, education, research, and future trends are analyzed. Representative guest lecturers from industry and government are invited to participate.

Second Semester

Technical Reporting

A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Appropriate form, conciseness, and accuracy are emphasized.

Technical Drawing

A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce legible, clear, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting.

Mineral Land Surveying

Surveying theory and practice applied to mineral lands. This field-oriented course includes traversing, leveling, mapping, and slope surveying.

Applied Physics

An elementary survey course covering the basic principles and concepts of mechanics, wave motion, sound, electricity, magnetism, heat, and optics.

Economics of Resources

Concepts of resources; interaction among resources, industrialization, and economic development; theories and problems of conservation; emphasis on mineral resources.

American Government Institutions

Organization and operation of governmental organizations at the national, state, and local levels and their responsibilities and activities which affect geological resources development and utilization.

Work Experience

On-the-Job Work Experience in Geological Technology

The student is given an introduction to various areas of geological technology through employment with a geological resources organization, usually during the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the geological technology principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The geological technology faculty keeps close contact with the student and his employer. A highly structured program and regular reports by the student add depth to the work experience.

Third Semester

Cartography

A laboratory course on map design and construction. The art and science of creating small-scale and large-scale maps as a medium for communication and research.

Metallic and Non-Metallic Minerals

A classroom and laboratory course covering the occurrence, mining, industrial utilization, marketing, and economics of metallic and non-metallic minerals.

Introduction to Coal, Oil, and Gas Geology

A classroom and laboratory course covering the properties, origin, migration, and occurrence of coal, oil, and natural gas deposits.

Gem Minerals

A classroom and laboratory course covering the physical and chemical properties of gemstones and their geologic occurrence. The laboratory emphasizes identification of gemstones.

Physics of the Earth

A lecture course covering the earth's origin, age, radioactivity, magnetism, seismology, structure and physical state of the earth's interior; continental drift; subcrustal currents; theories of mountain formation.

Fourth Semester

Aerial Photo-Interpretation

An introduction to the principles and practice of interpreting aerial photographs, with emphasis on identification of geological formations and development of maps.

Geophysical Surveying

A classroom and laboratory course covering the principles and applications of gravimetric, magnetic, electric, seismic, and radioactive prospecting.

Geology of North America

A lecture course covering the evolution of the structural-stratigraphic framework of the continent; and interpretation of relevant data obtained from field, experimental, and geophysical observations.

Geophysical Prospecting for Oil and Natural Gas

A classroom and laboratory course of seismic, gravimetric, magnetic, and other types of measurements used in prospecting for petroleum and natural gas.

Reclamation of Mined Lands

A classroom and laboratory study covering the methods and equipment used to restore vegetative cover to mined lands.

Final Extended Field Trip

Regional Geological Technology Practices

A three-week field trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current geological resources practices in his region. This field observation supplements the on-the job training experience of the previous summer and permits the student to observe prospecting techniques, mining practices, and mined-land reclamation operations which he has studied but may not have seen in operation.

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U.S. Civil Service Commission. *Federal Mine Inspectors Working Where It Counts.* Washington: U.S. Government Printing Office, 1971.

U.S. Department of Agriculture. *Restoring Surface-Mined Land.* Miscellaneous Publication No. 1082. Washington: U.S. Government Printing Office., 1968.

LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

American Geological Institute
2201 M Street, N.W.
Washington, DC 20037

American Geophysical Union
2100 Pennsylvania Avenue, N.W.
Washington, DC 20037

American Petroleum Institute
1271 Avenue of the Americas
New York, NY 10020

National Coal Association
Coal Building
1130 Seventeenth Street, N.W.
Washington, DC 20036

Chapter 5

OUTDOOR RECREATION TECHNOLOGY

DEFINITION

Webster's Dictionary[1] defines recreation as (1) refreshment in body or mind, as after work, by some form of play, amusement, or relaxation; (2) any form of play, amusement, or relaxation used for this purpose, as games, sports, hobbies, reading, walking, etc. Since recreational activities vary widely among individuals, one could say that recreation is a state of mind.

SCOPE

For the purposes of this publication, outdoor recreation includes the utilization for recreational purposes of fish and wildlife, forests and rangelands, and water.

ENVIRONMENTAL SIGNIFICANCE

The vast majority of the American people live and work in an urban or suburban environment. A steadily growing amount of leisure time has been at their disposal. Shorter work weeks and higher incomes have tended to increase the recreational activities of the people and an increasingly large share of leisure time has been devoted to outdoor recreation. Population growth has been a major contributor to increased use of outdoor recreation opportunities. The development of the U.S. Interstate Highway system has resulted in greater accessability of recreational areas which are located far from population centers.

A major portion of our urban and suburban areas lack adequate parks and open spaces in which the people may receive outdoor recreational experiences. The results of research investigations conducted by social scientists have implied that experiences in outdoor recreation and an appreciation of natural resources are essential to the spiritual and emotional well-being of our urbanizing population. Public interest in increasing the opportunities for participation in outdoor recreation has resulted in a considerable increase in outdoor recreation activities by Federal, state, and local government organizations. Governmental land planning organizations are encouraging the development of suburban residential areas and new towns which have adequate parks and open spaces for their inhabitants. State governments are acquiring additional lands for the establishment of state parks and are expanding and improving the facilities of existing parks. The Federal government is increasing the lodging and campground capacities of the U.S. National Parks, National Forests, and National Grasslands. Additional lands are being added to the National Wilderness Preservation System. Municipal governments have expanded and improved city parks. Large private landowners including some pulp and paper companies are allowing and providing for hunting, fishing, swimming, and picnicking activities on their land. Satisfying outdoor recreational experiences for our urbanizing population are essential to making America a pleasant country in which to live, work, and play.

[1] *Webster's New World Dictionary of the American Language.* College Edition. Cleveland and New York: The World Publishing Company. 1960.

TECHNICAL POSITION REQUIREMENTS

The commitment of the American people to the attainment of adequate outdoor facilities will require the recruitment and training of additional outdoor recreation technicians. These are needed to assist foresters, park superintendents, and park naturalists in providing opportunities for rewarding outdoor recreation experiences to the general public. Outdoor recreation activities have required and probably will continue to require a large amount of technical work between the skilled workmen and the professional foresters and park superintendents. This technical work has usually been done in the past by baccalaureate-level technologists, students working toward professional degrees, and other persons with or without formal training but with practical experience in some aspect of outdoor recreation, together with on-the-job training.

The outdoor recreation technician works under the general supervision of the professional recreation and parks scientist or manager. The technician is a person competent to occupy a responsible position in the line of authority between the skilled worker and the professional man. The technician often directs the activities of skilled workers. The outdoor recreation technician differs from the skilled worker in his theoretical and applied knowledge of outdoor recreation resources and differs from the professional man in his more limited or specialized background and in his use of technical skills in support of outdoor recreation resources management. The technician requires an education and training sufficient to enable him to understand the reasons for, and the purposes of, the specific operations for which he is responsible.

Competencies Required

Technicians who work with outdoor recreation resources must be capable of working and communicating with professional scientists, managers, and administrators as well as the skilled workers. Some technicians perform manipulative tasks while others supervise the application of such skills, but most do both. Their work involves objective analysis and problem solving, an understanding of the principles of science, engineering, mathematics, and statistics in addition to particular skills in outdoor recreation technology.

Personal Qualities

Outdoor recreation technicians must be in good health. Conducting opinion surveys of campground occupants or leading a group of park visitors on a nature field trip may require considerable physical stamina. Such personnel must enjoy working out-of-doors, sometimes in inclement weather. Outdoor recreation technicians must enjoy working with people.

Position Titles and Typical Duties

Outdoor Recreation Technician. Supervises crews and contractors, and participates in operation and maintenance of recreation sites; directs the establishment of landscape plantings; supervises skilled workmen or contractors engaged in controlling noxious insects and weeds; inspects for compliance with and enforces health and safety regulations on land and water areas; guides visitors to various natural areas and presents informative talks on geological formations, fossils, forest succession, wildlife biology, etc.; conducts public opinion surveys among campers and park visitors and

analyzes and summarizes these data for interpretation by the park or land manager.

TYPES OF EMPLOYERS

Employment opportunities for outdoor recreation technicians exist in Federal, state, and local government agencies, in educational institutions, and in private organizations and industries.

Outdoor recreation technicians may be employed by numerous public agencies of the Federal government including the National Park Service, the Forest Service, the Bureau of Outdoor Recreation, the Bureau of Land Management, and U.S. Army Corps of Engineers. Most permanent paraprofessional positions with Federal agencies are in the classified civil service. Advancement is usually based on demonstrated ability.

State governments employ outdoor recreation technicians in the following departments: Agriculture, Environmental Resources, and Parks and Recreation. The state parks are a major employer of outdoor recreation technicians. State positions are usually classified civil service posts and require a rating on a competitive entrance examination.

Employment opportunities also exist with many county or municipal governments which own and manage large parks.

Universities, colleges, and junior colleges which offer curricula in outdoor recreation or outdoor recreation technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff.

Opportunities for employment of outdoor recreation technicians by private organizations and industries are found in commerical recreational developments or company-owned parklands.

Outdoor recreation technicians employed by the Federal government usually receive a startling salary of about $6,500 per year. Positions with private organizations are generally comparable in salary with Federal government positions, while academic and state and local government positions usually pay slightly lower salaries. Technicians who demonstrate the ability to do more responsible work may be promoted to higher salaried positions.

EMPLOYMENT OUTLOOK

Employment opportunities for technicians trained in outdoor recreation are expected to be attractive and to increase for the forseeable future. In recent years, technicians have been one of the fastest growing occupational groups and it is expected that this rapid growth will continue. Numbers of park visitors and campers have been increasing rapidly over the past decade. Higher salaries, the shorter work week, and increasing population and urbanization will continue to create public demands for outdoor recreation opportunities from the federal, state and local governments and the private sector. The social desirability of providing the public with the quantity and quality of outdoor recreation experiences they want and need will continue to require the services of outdoor recreation technicians.

SUGGESTED OUTDOOR RECREATION TECHNICAL CURRICULUM

General Program Considerations

The objective of the total program of formal education for outdoor recreation technicians is to produce competent individuals capable of entering positions involving the recreational use of public and private lands and waters.

Because outdoor recreation technicians are employed in numerous and often specialized situations, the adequately trained technician must have attained the following abilities, scientific knowledge, and technical skills:

1. Facility with mathematics: The ability to use algebra and basic trigonometry as tools in the development of ideas that make use of scientific principles related to the recreational use of natural resources. A basic knowledge of statistical methods is required.
2. Proficiency in the application of scientific principles, including the basic concepts and laws of biology and geology which are pertinent to recreation and parks technology.
3. An understanding of the materials, processes, and techniques commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the scientific activities that distinguish the technology of the field, such as campground use census methods, park security measures, and park landscaping techniques.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.[2]

The technical program has the usually recogizable five subject matter divisions, namely: (1) specialized courses in the technology; (2) auxiliary or supporting technical courses; (3) mathematics courses; (4) science courses; and (5) general education courses. The technical subjects provide application of scientific and outdoor recreation technology principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is a accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms. General education courses constitute a relatively small part of the total program.

Curriculum Outline

COURSES

First Semester
- Communication Skills
- Applied Mathematics
- Elementary Biology
- Elementary Soils
- Introduction to Outdoor Recreation
- Physical Geology
- Outdoor Recreation Orientation Seminar

Second Semester
- Technical Reporting
- Technical Drawing
- Elementary Surveying
- Soil and Water Conservation
- Woody Plant Materials
- Fundamentals of Landscaping
- Basic Construction

Work Experience
- On-the-Job Work Experience in Outdoor Recreation Technology: Work Program, 10-16 weeks duration at 40 hours per week, usually during the summer months.

Third Semester
- Park Planning and Administration
- Construction of Recreational Facilities
- Forest Management
- Landscape Equipment
- Economics of Outdoor Recreation
- Basic First Aid

Fourth Semester
- Maintenance of Outdoor Recreational Facilities
- Wildlife Management
- Operation of Recreational Facilities
- Landscape Operations
- Forest and Park Protection
- Psychology of Human Relations

Final Extended Field Trip
- Regional Outdoor Recreation Practices: Three weeks of concentrated field observation at the close of the second year, at 40 hours per week.

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[2]Adapted from *Criteria for Technician Education – A Suggested Guide*. OE-80056, Washington, DC: U.S. Government Printing Office, 1968, page 3.

BRIEF DESCRIPTION OF COURSES

First Semester

Communication Skills
A program designed to develop greater competence in reading, writing, speaking, and listening.

Applied Mathematics
A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles, identities, and equations in surveying. Basic statistical concepts of measures of central tendency and dispersion are illustrated.

Elementary Biology
An elementary classroom and laboratory study of the forms and living processes of plants and animals. Morphology, physiology, development, life history, and ecology of plants and animals are covered.

Elementary Soils
A basic course in soil study to determine soil structure, soil chemistry, soil origin, soil types, soil organisms, and the recognition of soil components as they exist in nature. Laboratory exercises correspond to lecture material to provide a realistic understanding of soils.

Introduction to Outdoor Recreation
An overview of outdoor recreation with emphasis on current trends. Basic methods of planning and handling public recreation in forests, parks, and adjacent water areas are discussed. Laboratory consists of visits to outdoor recreation areas.

Physical Geology
Earth processes and their effects on the materials, structure, and morphology of the earth's crust. The laboratory includes the field observation and collection of rocks and minerals, identification of rocks and minerals, and the use of topographic maps.

Outdoor Recreation Orientation Seminar
A course designed to orient the beginning student in a post-high school educational program. The student is given occupational and professional orientation by means of panel reports and outdoor recreational personnel visits. Consideration is given to the broad historical aspects of recreational use of natural resources in Europe and the United States, outdoor recreation terminology, and outdoor recreation management policy at various levels. Current events in outdoor recreation activities are discussed. Outdoor recreation organizations at the various government levels are examined. A survey of the various kinds of occupations is made, and the demands and opportunities are stressed. Outside study is required. Outdoor recreation programs, education, research, and future trends are analyzed. Representative guest lectures from academia, industry, and government are invited to participate.

Second Semester

Technical Reporting
A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and form are emphasized.

Technical Drawing
A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce clear, legible, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting and outdoor recreation activities.

Elementary Surveying
Plane and topographic surveying, error theory, curves, and earthwork as related to land surveying, water control structures, and watershed mapping. The laboratory consists of field practice with surveying instruments.

Soil and Water Conservation
A study of the principles of conservation with emphasis on surveying, open and tile drainage systems, contouring, water impoundments, and mapping as they apply to soil and water conservation, parkland management, land use classification, land utilization for recreational purposes, and soil conservation organizations.

Woody Plant Materials
A detailed study of deciduous and evergreen trees, shrubs, and vines, their identification, growth habits, cultural requirements, and use in the landscape.

Fundamentals of Landscaping
Planning the composition of the landscape to obtain the best aesthetic appeal, while using the area for productive or recreational purposes.

Basic Construction
A laboratory course designed to develop competence with hand and power tools used in building wooden structures for recreational areas. The students build foot bridges, picnic tables, life guard chairs, wooden signs, etc.

Work Experience

On-the-Job Work Experience in Outdoor Recreation
The student is given an introduction to various outdoor recreation activities through employment with an organization concerned with the recreational use of natural resources, usually during the summer months between his freshman and sophomore years. However, in some areas of the United States opportunities for winter work experience as a snow ranger are available through the U.S. Forest Service. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the outdoor recreational principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semester. The outdoor recreation faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Park Planning and Administration
The design and administration of parks and other recreational facilities. The course includes the administrative uses of soil and topographic maps, vegetation surveys, opinion surveys of park clients, park supplies, security, staff organization and duties, and public relations.

Construction of Recreational Facilities
A lecture and laboratory course which covers the important features, methods, and materials for frame and concrete construction with installation of plumbing, electrical, and heating lines and fixtures.

Forest Management
Methods of managing forests for multiple use objectives (wood, water, wildlife, forage, and recreation), with special emphasis on the recreational use of forest lands.

Landscape Equipment
The problems and techniques of use of various hand tools and power machines designed for establishment and maintenance of landscape plantings are put into "hands-on" practice.

Economics of Outdoor Recreation
The study of economic principles as they apply to outdoor recreation. How and where the recreation dollar is spent and the implications for recreation planners, agencies, and enterprises.

Basic First Aid

Measures and materials used in administering first aid to the injured.

Fourth Semester

Maintenance of Outdoor Recreational Facilities

A lecture and laboratory course to provide knowledge and develop exploratory skills of the student in maintenance, repair, and custodial service for recreational facilities.

Wildlife Management

The science of managing waterfowl, furbearers, small game and big game for optimum sustained yield in the face of increasing outdoor recreational and environmental pressures.

Operation of Recreational Facilities

A lecture course covering the general subject of recreation management with emphasis on people management, general concepts of resources, protection, interpretation, nature programs, law enforcement, and work plans.

Landscape Operations

A course which covers all aspects of establishing and maintaining a totally designed recreational or parkland landscape. The course illustrates the practical applications of entomology, plant pathology, soil science, landscape construction, and design.

Forest and Park Protection

A lecture and laboratory course covering the theories, practices, materials, and equipment for protecting forests and parks from damage by insects, plant diseases, weeds, etc. Methods of protecting the health of park and forest visitors by controlling insect and rodent disease vectors are covered.

Psychology of Human Relations

Introduction to general psychology and principles of human behavior. Techniques of persuasion, attitude formation, and change are demonstrated.

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U.S. Department of Health, Education, and Welfare, Public Health Service. *Environmental Health Practice in Recreational Areas.* Public Health Service Publication No. 1195. Washington: U.S. Government Printing Office, 1966.

U.S. Department of the Interior, Bureau of Outdoor Recreation. *Education and Outdoor Recreation.* Washington: U.S. Government Printing Office, 1968.

LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

American Association for Health,
Physical Education and Recreation
1201 16th Street, N.W.
Washington, DC 20036

American Camping Association, Inc.
Bradford Woods
Martinsville, IN 46151

American Forestry Association
1319 18th Street, N.W.
Washington, DC 20036

American Society of Landscape Architects, Inc.
2013 I Street, N.W.
Washington, DC 20006

Association of Interpretive Naturalists
125 East Broad Street
Columbus, OH 43205

National Recreation and Park Association
1700 Pennsylvania Avenue, N.W.
Washington, DC 20006

Society of American Foresters
Suite 300
1010 16th Street, N.W.
Washington, DC 20036

Chapter 6
SOIL TECHNOLOGY

DEFINITION

Soil may be defined as (1) a dynamic natural medium on the surface of the earth in which plants grow, composed of mineral and organic materials, water, air and biota; (2) the collection of natural bodies occupying parts of the earth's surface that support plants and that have properties due to the integrated effect of climate and living matter acting upon parent material, as conditioned by topography, over periods of time.

SCOPE

Soil is virtually continuous over the land surface of the earth, except for bare rocks and the polar ice caps.

ENVIRONMENTAL SIGNIFICANCE

Soil formation generally consists of two concurrent phases: an accumulation of soil parent material, and differentiation of horizons in the profile. The weathering of rock by air, water, and ice provides soil parent material. Large quantities of rock have been weathered during the millions of years since the continents were formed. A layer of weathered rock, called the regolith, now covers most of the earth's land surface. As organisms grow and die, their organic residues become incorporated into the regolith and the A horizon or surface soil eventually becomes differentiated. With the passage of time and the leaching and eluviation of the A horizon by water percolation, the B horizon or subsoil is formed. Several subdivisions eventually develop within each horizon.

Soil overlays the rock core of the earth. Soil provides anchorage for terrestrial flora. Plants obtain essential minerals and water through their root systems which are embedded in the soil.

The surface soil and subsoil provide a habitat for a multitude of plant and animal species. Saprophytic microorganisms (which break down dead organisms) live in the soil, as well as many plant and animal pathogens, including bacteria, fungi, nematodes, mites, and insects. The soil fauna are important in soil transport and aeration. The soil contains microorganisms, such as the nitrifying bacteria, which chemically alter compounds into forms which are more readily available for plant nutrition.

Many chemical elements circulate in the biosphere from the soil to the biota and back to the soil. Such pathways are called biogeochemical cycles. Soil is an important component of the biogeochemical cycles of nitrogen, phosphorus, and potassium.

The physical characteristics of soil partly determine its suitability for various human purposes. These characteristics include organic matter, texture, structure, porosity, weight, moisture, and temperature. Soil texture is defined as the relative amounts of different size groups of individual soil grains (sand, silt, and clay). Soil structure is the spatial arrangement of the individual soil particles. Porosity is the percent of the soil mass which is not occupied by solid particles. Variability in organic matter, texture, structure, porosity, and temperature have important effects upon plant growth. Soil particles range in diameter from clay (less than 0.002mm) through silt (0.002-0.05mm) to sand (0.05-2.00mm) and coarser. The smallest particles possess a very large surface area per unit of volume. Clay soils are, therefore, more efficient in retaining water as well as mineral cations and anions by absorption. Sandy soils are less efficient in retaining water and minerals because they possess a much smaller surface area per unit of volume. Dense clay layers in soils often inhibit plant growth by their impenetrability to roots and by retaining excessive water and insufficient oxygen. Bare and dry soils can absorb enough solar radiation to raise surface temperatures beyond the survival levels of plants and seeds.

Soil is an important element of the hydrologic cycle. The upper levels of the soil (aeration zone) retain a portion of the precipitation for use by green plants. Deeper levels and rock strata (saturation zone) serve as a storage facility for ground water which percolates down from the land surface. Ground water sources supply water to our lakes, rivers, streams, and wells.

The U.S. Soil Conservation Service estimates that 220 Million acres of crop land are affected by wind and water erosion resulting in an annual loss of one billion dollars. Every year thousands of houses and other buildings are destroyed or damaged because they were built on soils that would not support them. Reservoirs became filled with silt because sound soil conservation practices were not carried out. Many acres of agricultural and forest lands are less productive because their soils are illsuited to their present vegetation. Sanitation problems arise from the location of septic tank filter fields in soils which are poorly drained. Knowledge of what soil does under physical stresses is essential to environmental enhancement and economical land use.

TECHNICAL POSITION REQUIREMENTS

Soil conservation always has required a large amount of technical work in the area between the soil scientist and the people requiring a knowledge of soil (farmers, ranchers, urban planners, construction engineers, foresters, etc.). In the past, this technical work has been done by professional soil conservationists and aids, students working toward professional degrees, and other persons with or without formal training but with practical soil conservation experience and on-the-job training. It is anticipated that technicians will accomplish many of the tasks in the area between professionals and land managers in the future.

Recent technological advances in the development, maintenance, regulation, and protection of soil resources have created a shortage of highly trained technicians who are needed to assist soil scientists in several environmentally important tasks. Providing adequate food and fiber for an expanding population on a static land base will require increased efforts in soil conservation. One-fifth of the potential cropland acreage of the United States requires intensive conservation treatment even for limited cultivation. Soil conservation practices are necessary for maintaining the forests and rangelands that provide water, forage, wildlife, and recreation. Maintenance of a sustained yield of wood products from our forests requires maintenance of suitable forest soils. Knowledge of soil properties is essential for reclaiming mined lands and the establishment of a vegetative cover to ameliorate environmental conditions. Soil surveys provide data on soil properties and permit intelligent land use decisions.

Competencies Required

Soil conservation technicians must be capable of working and communicating with a wide range of professional scientists, such as soil conservationists, biologists, soil scientists, range management

specialists, foresters, agronomists, and engineers. In addition, soil conservation technicians must be able to communicate with farmers, ranchers, land appraisers, city councilmen, and others whose land use activities require a knowledge of soil conservation. Technicians usually spend most of their time performing manipulative tasks, such as analyzing soil properties and compiling such data for use by the professional scientists. Their work is distinguished from that of the skilled worker primarily in that it is less repetitive, involves more objective analysis and problem solving, and requires an understanding of the principles of science, engineering, mathematics, and statistics in addition to particular skills in soil conservation techniques.

Personal Qualities

Technicians must be in good health because many soil studies are conducted on rough terrain. Such personnel must enjoy working out-of-doors, sometimes in inclement weather. Technicians must be capable of carefully following directions from their superiors and communicating these directions to farmers, ranchers, land planners, and other persons responsible for land use. Technicians must be tactful and courteous in answering questions and explaining soil conservation practices to land managers.

Position Titles and Typical Duties

Soil Conservation Technician. Works with soil conservationists, land planners, and engineers to promote and implement soil conservation practices. The technician works with the soil conservationist to help local people in rural and rural-fringe areas prepare conservation development plans for communities and individual operating units to meet local needs. The soil conservation technician visits farms, ranches, municipal watersheds, etc., and collects data such as amounts of soil erosion, land use, and types of vegetative cover. The soil conservationist interprets the data and determines which type of soil conservation measures are necessary to prevent or reduce damage to the soil resources. The technician meets with the appropriate landowner and assists him in carrying out such soil conservation practices as contour plowing, strip-cropping, changing land use from cropping to grazing, planting cover crops on steep banks to reduce soil erosion, and selection and planting of appropriate plant species for establishment of windbreaks.

Soil Research and Development Technicians. Works with soil scientists in the determination of soil properties and the development of soil surveys. The technician collects information about soils from examination of soil survey maps, aerial photographs, and by obtaining soil samples from the study area. The technician conducts laboratory analyses of the physical and chemical properties of soil. The soil scientist then interprets and integrates the data collected, analyzed, and summarized by the soil research and development technician. The technician then conveys the recommended land uses which are appropriate to the physico-chemical properties of the soil to the person or organizations responsible for land management decisions.

TYPES OF EMPLOYERS

Soil conservation and soil research and development technicians may be employed by the large public agencies of the Federal government. Most professional and paraprofessional soil specialists are employed by the Soil Conservation Service and the ARS (Agricultural Research Service) of the U.S. Department of Agriculture, but most positions are at the local level. Many soil technicians are also employed by the Bureau of Land Management, Bureau of Indian Affairs, and the National Park Service of the U.S. Department of the Interior, and by the Forest Service of the U.S. Department of Agriculture. A few soil technicians are employed to assist soil specialists with the Bureau of Outdoor Recreation, Department of Defense, Department of Commerce, Department of Housing and Urban Affairs, and Tennessee Valley Authority. All permanent paraprofessional positions in the Soil Conservation Service and in most other federal agencies are in the classified civil service. The U.S. Civil Service Commission gives entrance examinations each year. Advancement is based on ability.

Soil technicians may find employment at the state level with the Department of Agriculture, Department of Environmental Resources and the Department of Urban Development. State positions are usually classified civil service posts and require a rating on a competitive entrance examination.

Employment opportunities also exist with many county or city governments which are involved in urban development, expansion of transportation facilities, water supplies, recreation, and wildlands preservation.

Universities, colleges, and junior colleges which offer curricula in soil science or soil technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff.

Soil technicians employed by the Federal government usually receive a starting salary of about $6,000 per year. Technicians who demonstrate the ability to do more responsible work will be promoted to higher grade positions. State, county, and municipal government positions generally pay slightly lower salaries than Federal government positions.

EMPLOYMENT OUTLOOK

Employment opportunities for technicians are expected to increase at a moderate rate for the foreseeable future. In recent years, technicians have been one of the fastest growing occupational groups and it is expected that this rapid growth will continue. The necessity of providing the nation with a suitable soil resource which will enable the sustained production of food and fiber and will provide for adequate water supplies and recreational opportunities should ensure a bright future for technicians. A consideration of soil behavior and soil capabilities will become increasingly important in land planning and the continuing development of the country's housing, industries, and transportation network.

SUGGESTED SOIL TECHNOLOGY CURRICULUM

General Program Considerations

The objective of the total program of formal education for soil technicians is to produce competent individuals capable of carrying out a wide variety of field and laboratory soil testing techniques.

Because soil technicians are employed in various and often specialized duties, the adequately trained soil technician must have attained the following abilities, scientific knowledge, and technical skills:

1. Facility with mathematics: The ability to use the algebra and basic trigonometry needed in order to apply scientific principles related to soil studies and problems. A basic knowledge of statistical methods is required.
2. Proficiency in the application of scientific principles, including the basic concepts and laws of physics, chemistry, and biology pertaining to soil technology.
3. An understanding of the materials, processes, and techniques commonly used in soil technology.
4. An extensive knowledge of a particular field of specialization with an understanding of the scientific activities that distinguish the technology of that field, such as soil taxonomy, mechanical analysis of soil sampling methods, cation exchange capacity, and methods of soil erosion control.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.[1]

The technical program has the usually recognizable five subject matter divisions, namely: (1) specialized courses in the technology; (2) auxiliary or supporting technical courses, (such as

[1] Adapted from *Criteria for Technician Education – A Suggested Guide.* OE-80056, Washington, DC: U.S. Government Printing Office, 1968, page 3.

technical report writing and soil technology seminars); (3) mathematics courses; (4) science courses (such as botany and chemistry); and (5) general education courses. The technical subjects provide application of scientific and soil conservation and development principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. The coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms. General education courses constitute a relatively small part of the total program.

Curriculum Outline

COURSES

First Semester
- Elementary Agricultural Chemistry
- Communication Skills
- Applied Mathematics
- Botany
- Elementary Soils
- Soil Technology Orientation Seminar

Second Semester
- Technical Reporting
- Elementary Surveying
- Psychology of Human Relations
- Crop Production
- Agricultural Fertilizers

Work Experience
- On-the-Job Work Experience in soil development, reclamation, or conservation: Work Program, 10-16 weeks duration at 40 hours per week, usually during the summer.

Third Semester
- Advanced Soils
- Introduction to Forest and Rangeland Management
- American Government Institutions
- Introduction to Watershed Management
- Technical Drawing

Fourth Semester
- Elements of Social Science
- Reclamation of Disturbed Lands
- Conservation Problems
- Irrigation and Soil and Water Conservation
- Aerial Photo-Interpretation

Final Extended Field Trip
- Regional Soil Development and Conservation Practices — Three weeks of concentrated field observation at close of second year, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Agricultural Chemistry
An elementary course in the theory and basic principles of inorganic and organic chemistry. Special emphasis is placed on the mineral elements essential to soil fertility.

Communication Skills
A program designed to develop greater competence in reading, writing, speaking, and listening.

Applied Mathematics
A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles, identities, and equations in surveying. Basic statistical concepts of measures of central tendency and dispersion are illustrated.

Botany
An elementary classroom and laboratory study of the forms and living processes of seed plants. It includes a study of the structure and function of roots, stems, leaves, flowers, and seeds. Physiological processes and responses to stimuli, and a study of plant heredity are included.

Elementary Soils
A basic course in soil study to determine soil structure, soil chemistry, soil origin, soil types, soil organisms, and the recognition of soil components as they exist in nature. Laboratory exercises correspond to lecture material to provide a realistic understanding of soils.

Soil Technology Orientation Seminar
A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and soil resources personnel visits. Consideration is given to the broad historical development of soil resources development and conservation in Europe and the United States, soil terminology, and soil management policy at various levels. Current events in soil conservation activities are discussed. Soil resources organizations at the various governmental levels are examined. A survey of the various kinds of occupations is made, and the demands and opportunities are stressed. Outside study is required. Soil resources programs, education, research, and future trends are analyzed. Representative guest lecturers from industry and government are invited to participate.

Second Semester

Technical Reporting
A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and form are emphasized.

Elementary Surveying
Plane and topographic surveying, error theory, curves, and earthwork as related to land surveying and soil mapping. Laboratory consists of field practice with surveying instruments.

Psychology of Human Relations
Introduction to general psychology and principles of human behavior. Techniques of persuasion, attitude formation, and change are demonstrated.

Crop Production
A basic course in the study of crop varieties, adaptation to growing conditions; crop uses, climatic and moisture requirements; an understanding of cultural practices for maximum production under existing conditions.

Agricultural Fertilizers
A study of primary, secondary, and micro plant food nutrients; the values of commercial fertilizers, time and rates of application, and methods of fertilizer application.

Work Experience

On-the-Job Work Experience in Soil Technology
The student is given an introduction to various areas of soil technology through employment with a soil resources organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the soil technology principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The soil technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Advanced Soils
A detailed study of soil surveys, laboratory exercises in soil analyses for determining soil nutrient deficiencies and soil structure; the determination of soil additives for maximum crop production as well as cultural practices for proper soil tilth.

Introduction to Forest and Rangeland Management

Methods of managing forests and rangelands for multiple-use objectives (wood, water, wildlife, forage, and recreation), with special emphasis on the pervasive role of soil resources.

American Government Institutions

Organization and operation of governmental organizations at the national, state, and local levels and their responsibilities and activities which affect soil resources.

Introduction to Watershed Management

Basic elements of watershed management; effects of precipitation on streamflow as moderated by the interaction of soil and vegetation with available water.

Technical Drawing

A beginning course for students who have had little or no previous experience in drafting. The principle objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings and to produce clear, legible, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting and soil resources management activities.

Fourth Semester

Elements of Social Science

An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles, and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society in general.

Reclamation of Disturbed Lands

Principles of soil technology as they relate to reclamation of spoil banks, salt-damaged vegetation, and severely eroded sites. Selection and planting of appropriate plant species to ameliorate site conditions enough to permit the eventual establishment of an adequate vegetative cover that will conserve soil and water resources.

Conservation Problems

A survey of current regional soil conservation problems and discussion of various corrective measures and their relative effectiveness.

Irrigation and Soil and Water Conservation

Includes the importance of irrigation in crop production, methods of irrigation; the amounts of moisture required for optimum plant growth; conservation practices to conserve soil and moisture in crop production.

Aerial Photo-Interpretation

An introduction to the principles and practices of interpreting aerial photographs with emphasis on using aerial photographs for mapping and determination of vegetation types and topographical features.

Final Extended Field Trip

Regional Soil Development and Conservation Practices

A three-week field trip to provide concentrated and varied field observations. It is conducted at the end of the fourth semester to give the student first-hand observation of the current soil development, reclamation, and conservation practices in his region. This field trip supplements the on-the-job training experience.

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U.S. Department of Agriculture, Soil Conservation Service. *A Soil Science Career for You in SCS*. Miscellaneous Publication No. 716. Washington: U.S. Government Printing Office, 1971.

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LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

American Society of Agronomy
Crop Science Society of America
Soil Science Society of America
677 South Segoe Road
Madison, WI 53711

Soil Conservation Society of America
7515 N.E. Ankeny Road
Ankeny, IA 50021

Society of American Foresters
Suite 300
1010 16th Street, N.W.
Washington, DC 20036

Society for Range Management
2120 South Birch Street
Denver, CO 80222

Chapter 7

URBAN - REGIONAL PLANNING AND LANDSCAPE ARCHITECTURE TECHNOLOGIES

DEFINITION

Land space resources comprise all of the uses which are made of land by a modern industrialized society. Land uses include agriculture, forestry, transportation facilities, watersheds, recreation areas, industry, housing, health care facilities, and scenic areas.

SCOPE

Land use in the land area of the United States may be classified in the following categories (in percent): forest, 33; range, 28; cropland, 20; miscellaneous (marshes, sand dunes, bare rock, desert), 12; special uses (park, wilderness areas), 5; urban development (cities, highways, railroads, airports, etc.), 2.

ENVIRONMENTAL SIGNIFICANCE

The problems and opportunities for wise use of land space resources are intimately related to human population and its distribution and requirements in a modern urbanizing society.

There are widely divergent views among demographers concerning the optimum or maximum desired population of the United States. However, few would disagree that population shifts of the last two decades have had very detrimental effects on many rural areas, while simultaneously greatly aggravating urban problems. Lack of employment opportunities and community services have caused many inhabitants of rural areas to migrate to large urban areas. These immigrants have increased the serious problems of providing adequate employment, welfare, public services, and health facilities for the people of the central cities.

Modern transportation facilities, higher incomes, and a shorter work week have enabled millions of people to migrate from the cities and establish residences in suburban and rural areas. This outward migration has caused many problems in rural areas, including urban sprawl; high taxes; air, water, and land pollution; and a wasting of natural resources. In some communities it has caused a premature decline of local agriculture and of related processing and service industries. Unplanned community growth often has produced conflicts between neighboring land uses, for example, between agricultural and residential uses or between industrial and recreational uses. The American landscape is replete with examples of unwise land use. Homes, factories, roads, and sewage disposal systems have been damaged or destroyed because the soil had poor bearing qualities or a high degree of shrink-swell characteristics. Residential and industrial areas constructed on flood plains are subject to periodic damage from floods. Because of the high costs involved, scattered and random encroachment of residential subdivisions and nonfarm residences into rural areas result in inadequate public services to these homes. The development of businesses along main highways result in traffic congestion and customer inconvenience.

Planning, zoning, and related controls were some of the remedial measures adopted by rapidly expanding urban centers in the early 1900's. However, planning and zoning measures designed solely for urban areas are no longer adequate for our evolving and expanding economy. Measures are needed to guide development and growth in both urban and rural areas. The wise use of land space resources can provide for public health, safety, and welfare wherever people choose to live, work, and play.

The following quotation on the environmental significance of urban planning is from pages 1, 3, and 4 of *Planning and Zoning for Better Resource Use*, listed under selected references.

> Although planning and zoning are sometimes closely related, there is a great difference between the two, and the terms should not be confused.
>
> Planning is intelligent forethought applied to the development of a community. A comprehensive plan is a blueprint to show how present and future land uses should be related.
>
> Zoning is a basic regulatory technique to carry out the land use portion of the plan. Several other related control techniques are also available.
>
> Local governments must look to their state legislatures for authority to plan and zone. Such powers are usually granted in enabling statues that also prescribe the geographic and functional scope of the planning activities that may be performed and of the zoning regulations that may be adopted. These enabling statutes permit cities, towns, counties, and other units of government to adopt and apply ordinances and regulations to zone the land.
>
> Zoning is "The regulation by districts under the police power of the height, bulk, and use of buildings, the use of land, and the density of population."[1] This definition embraces the four main groups of zoning regulations that are generally enacted: building–size regulations, building–tract (area) regulations, density-of-population regulations, and use regulations.
>
> Building – tract regulations may be employed to set minimum restrictions on size of lots or tracts, set-backs, side and rear yards, and permissible lot coverage. Building – size regulations may be used to restrict the height and size of buildings and other structures. Both types of regulations may be used to influence population densities and to assure adequate light and air around buildings. In areas with large lots and one-story houses, population densities are low, while in areas with small lots and multi-story houses, population densities are high. A zoning innovation authorized in several states allows flexibility in grouping residential buildings and open spaces to fit natural and topographic features of the area under development. Planned residential development, along with cluster zoning and layout, promises greater variety and amenity; it also reduces soil erosion and urban sprawl that result in waste of land and in road, utility, and public service expenditures.
>
> The most important of the regulations are use regulations which permit local governing bodies to divide their communities into several kinds of zoning districts. Separate districts can be established for farming, homes, business, industry, forestry, recreation, flood control, conservation, and so on. Once a district is established, only those proposed uses of land, buildings, and structures that are compatible with other uses need be allowed. Harmful uses can be avoided and land uses that may conflict can be kept apart.
>
> These four groups of zoning regulations are most useful in cities and on the urban fringe where land is used intensively for nonfarm purposes. Only a few of the regulations are useful in farm, ranch, or forest districts.
>
> **Objective of Planning**
>
> Why plan anyway? Why not let the community grow as a summation of individual decisions? What are the purposes of comprehensive plans and of collective community action?
>
> Objectives of landuse plans will differ by communities. Objectives will be different in growing, urbanizing

[1] Bassett, Edward M. *Zoning. The Law, Administration, and Court Decisions During the First 20 Years.* New York: Russell Sage Foundation. 1936. page 45.

ties than in stable or declining farm communities. Comprehensive plans are made for and by the community's people. Unless planning objectives reflect their wishes, the plans will not be carried out.

Urbanizing Communities. In communities that are becoming urbanized, a judicious blending of urban-oriented and rural-oriented planning objectives is needed. Urban-oriented objectives might include:

1. Protecting the health, safety, and general welfare of the community.
2. Providing a unifying framework to guide public and private construction toward common goals.
3. Encouraging industrial, commercial, and residential development in areas where public service facilities can be adequately and economically provided.
4. Preventing scattered, sprawling, haphazard suburban development and its ugly, costly, wasteful aftermath.
5. Developing attractive residential areas and avoiding odorous septic tank subdivisions.
6. Reserving the best agricultural areas for farming by reducing urban pressures on productive agricultural areas and encouraging the location of proposed roads; sewer, water, and gas lines; schools; and other public service facilities in other suitable areas.
7. Encouraging and maintaining a balanced economic base, including the agricultural base and related processing and servicing activities.
8. Encouraging areawide thinking about problems and opportunities that transcend local boundaries, including highways, sewers, water supply, and land use.
9. Protecting historical and scenic values and natural beauty and saving stream valleys, selected wooded areas, and steep slopes for parks and open spaces.
10. Proposing a program that will result in savings from advanced land acquisition for roads and streets, schools, parks, and other public facilities.
11. Proposing a capital improvement program designed to avoid emergency needs and to create a stable tax structure.
12. Getting the most out of each tax dollar by coordinating city, town, county, state, and Federal policies and planning as a unified program.

Stable Farm Communities. Many urban-oriented planning objectives are also appropriate for stable farming areas. Similarly, some of the following rural-oriented planning objectives are suitable for urbanizing communities:

1. Encouraging the development, use, and conservation of natural resources, including land, soil, minerals, water, forests, recreational potentials, and fish and wildlife.
2. Discouraging wasteful and costly suburban sprawl and protecting the natural beauty of the country side by encouraging reasonably compact suburban development.
3. Promoting agricultural development by encouraging either intensification (from grazing to row crops) or extensification (from row crops to grazing or forestry), depending upon the basic resources and the local situation.
4. Preventing pollution of air, land, and water by industrial, municipal, or agricultural activities.
5. Ensuring that new development in the community will produce a maximum of order, convenience, and economy consistent with other objectives.

Declining Farm Communities. Planning objectives proposed for declining farm communities, but often appropriate for other communities, include:

1. Raising the income levels of both farm and nonfarm populations.
2. Establishing a sound basis for financing and raising educational levels.
3. Providing adult vocational training and retraining.
4. Reserving suitable commercial and industrial land to encourage new industry and employment.
5. Providing adequate and efficient public services.
6. Improving the economy by intensification or extensification of agriculture and forestry where appropriate.
7. Guiding marginal farmland and wasteland into economic forest and recreational uses, or into multiple uses where feasible.
8. Developing potential recreation and wildlife areas.

Many other objectives could be set for both urban and rural areas. Planning objectives will necessarily differ by communities. Each community must decide whether it wants orderly growth through thoughtful planning or chaotic sprawl as a result of doing nothing.

Many of the Nation's urban, suburban, and rural areas are scarred by the wasteful, ugly, and dangerous results of unplanned economic expansion. Abandoned factories, mines, and farms mar the natural landscape. Fertile topsoil has been eroded from steep banks which have been denuded of vegetative cover. Extensive spoil banks create ugliness and danger for inhabitants of mining regions. Large areas of our cities are concrete jungles, completely devoid of grass, shrubs, and trees. Many new suburban developments have been built without adequate provision of open space, parks, and recreational areas.

The increasing urbanization of the American landscape has aroused public interest in developing, maintaining, and protecting aesthetic and recreational values within an urban setting. Landscape architects and landscape architecture technicians are needed to provide amenities in the urban environment. Vegetative cover can be established on steep slopes and mining spoil banks to provide protection to soil, water, and fish and wildlife resources. Belts of trees and shrubs can be planted between highways and residential areas to provide a screen against headlights and noise. City parks can be developed and expanded to create suitable habitats for songbirds and small animals. Urban vegetation can serve as an air pollution filter and a contributor to the oxygen supply of the ambient air. Rows of curbside trees and shrubs can contribute to a pleasing street vista as well as ameliorate summer temperatures. Proper landscaping of new suburban developments can enhance their beauty by blending landscaping with the natural vegetation and topography. Recreational and wildlife resources in and around suburban developments can be enhanced by the establishment of selected plant species and the application of appropriate landscaping techniques. Trees and shrubs can be used effectively to screen unsightly industrial plants and public utility installations.

TECHNICAL POSITION REQUIREMENTS

Technicians who assist urban planners, civil engineers, and landscape architects engage in the development, maintenance, regulation, and protection of landscape resources generally work in one of two broad areas: (1) Urban and Regional Planning Technology and (2) Landscape Architecture Technology.

Urban and regional planning technicians assist professional urban and regional planners and civil engineers in developing and implementing plans for the wise use of land in urban, suburban, and rural areas.

Landscape architecture technicians assist professional landscape architects and civil engineers in planning, establishing, and maintaining soil, vegetation, and landscape structures (such as patios, walks, etc.) for recreational and aesthetic benefit in urban and suburban areas.

Recent technological advances in the development, maintenance, regulation, and protection of land space resources have created a serious shortage of highly trained technicians. The management of land space resources always has required and will continue to require a large amount of technical work between the skilled workman and the professional planner, engineer, landscape architect, and administrator. This technical work has usually been accomplished in the past by baccalaureate-level technologists, students working toward professional degrees, and other persons with or without formal training but with practical experience in some aspect of land space resources and on-the-job training.

Urban and regional planning technicians work under the general supervision of professional urban and regional planners while landscape architecture technicians are supervised by professional landscape architects and civil engineers. The technician is a person competent to occupy a responsible position in the line of authority between the skilled worker and the professional planner, landscape architect, or engineer. The technician often directs the activities of skilled workers. These technicians differ from the skilled worker in their theoretical and applied knowledge of land space resources. They differ from the planner, architect, and engineer in their use of technical skills in support of land space resource management. The urban and regional planning and landscape architecture technicians require an education and training sufficient to enable them to understand the reasons for, and the purposes of the operation for which they are responsible.

A large number of skilled paraprofessional personnel have been employed in land space resources for several years. However, the

need for formally educated technicians in land space resources is a comparatively recent development. Urban planning technicians assist urban and regional planners and civil engineers in collecting public opinion data on highway location, urban renewal, housing development, and establishment of parks and other recreational facilities. The technician collects field data, such as soil samples, and collects, analyzes, and presents data on topography, condition of buildings, population density, and location and number of employees in business and industrial establishments. Urban planning technicians draft maps and detailed drawings of proposed parks, housing developments, and zoning regulations.

Landscape architecture technicians assist landscape architects and civil engineers gathering data on soil, topography, vegetation, and type of structures in areas of proposed landscaping operations. They often supervise skilled construction workers in carrying out the landscaping operation.

Competencies Required

Technicians who work with land space resources must be capable of working and communicating with professional planners, landscape architects, and engineers as well as the skilled workers whom the technicians must supervise. Some technicians perform manipulative tasks while others supervise the application of such skills, but most do both. Their work is distinguished from that of the skilled worker primarily in that it is less repetitive, involves more objective analysis and problem solving, and requires an understanding of the principles of science, engineering, mathematics, and statistics in addition to their own particular skills in urban planning technology or landscape architecture technology.

Personal Qualities

Land space resources technicians must be in good health. Conducting vegetation surveys or conducting public opinion surveys in a ghetto area require considerable physical stamina. Such personnel must enjoy working out of doors, sometimes in inclement weather. Technicians must be willing to travel over a large area and often visit inner city slums and dirty factory towns. Technicians must be capable of carefully following directions from their supervisors and communicating these directions to the skilled workers. They must be tactful and courteous in answering questions and explaining regulations to the general public and to representatives of local government.

POSITION TITLES AND TYPICAL DUTIES

Urban and Regional Planning Technology

Urban and Regional Planning Technician. Conducts public opinion surveys to determine how urban dwellers view their needs. Collects, analyzes, and summarizes demographic, economic, geographic, topographic, sociological, and legal data for interpretation and evaluation by urban planners and civil engineers. Prepares maps, graphs, charts, sketches, and other visual aids to illustrate the present and proposed locations of highways, parks, buildings, power lines, rapid transit tracks, parking areas, schools, hospitals, etc. Prepares zoning maps of cities and suburbs. Often presents talks to local government officials and the general public.

Landscape Architecture Technology

Landscape Architecture Technician. Visits site where landscaping has been proposed and collects field data on soil, topography, vegetation, roads and paths, and location of buildings and other structures. Analyzes and summarizes field data for proposed landscaping operation. Selects material, equipment, and plant species for the landscaping operation. May supervise the skilled workers who operate the construction equipment and establish the desired vegetation. The technician may be responsible for directing crews of skilled workmen in the maintenance and protection of landscaped areas. Often presents talks to local government officials and the general public.

TYPES OF EMPLOYERS

Urban and Regional Planning Technology

Opportunities for employment for urban planning technicians exist in Federal, state, and local government agencies, in educational institutions, and in private organizations and industries.

Urban planning technicians may be employed by the large public agencies of the Federal government. Large numbers of these technicians are employed by the Department of Housing and Urban Development. Other Federal agencies employing urban planning technicians are the Department of Health, Education, and Welfare, Department of the Interior, Department of Transportation, and Department of Agriculture. Most permanent paraprofessional positions with federal agencies are in the classified civil service. Advancement is usually based on ability.

State governments employ urban planning technicians in their departments of Housing, Public Health, Transportation, Recreation and Parks, and Natural Resources. State positions are usually classified civil service posts which require a rating on a competitive entrance examination.

Local governments employ urban planning technicians in their departments of Public Works, Health, Recreation and Parks, and Housing.

Public planning agencies (Federal, state, regional, county, and city), employ many urban planning technicians to accomplish their field studies

Universities, colleges, and junior colleges which offer curricula in urban planning, or urban planning technology, need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff and may range in academic rank from research assistant to instructor.

Various consulting firms involved in land planning and industries, such as power companies and real estate developers, need the services of urban planning technicians.

Landscape Architecture Technology

Opportunities for employment for landscape architecture technicians exist in Federal, state, and local government agencies, in educational institutions, and in private organizations and industries.

Landscape architecture technicians may be employed by the large public agencies of the Federal government. These technicians may be employed by the following departments: Housing and Urban Development; Health, Education, and Welfare; Interior; Transportation; Commerce; and Agriculture. Most permanent paraprofessional positions with Federal agencies are in the classified civil service. Advancement is usually based on ability.

State governments employ landscape architecture technicians in their departments of Housing; Public Health; Transportation; Recreation and Parks; and Natural Resources. State positions are usually classified civil service posts which require a rating on a competitive entrance examination.

Local governments employ landscape architecture technicians in their departments of Public Works; Health; Recreation and Parks; and Housing.

Universities, colleges, and junior colleges which offer curricula in landscape architecture, or landscape architecture technology, need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff and may range in academic rank from research assistant to instructor.

Many landscape architecture technicians are employed by private organizations and industries to develop, maintain, and protect vegetation and structures around buildings, factories, parking lots, arboreta, estates, etc.

Urban planning and landscape architecture technicians employed by the Federal government usually receive a starting salary of about $6,000 per year. Positions with private and industrial organizations are generally comparable in salary with Federal government positions, while academic and state and local government positions usually pay slightly lower salaries than Federal government and industrial positions. Technicians who demonstrate

the ability to do more responsible work are promoted to higher salaried positions.

EMPLOYMENT OUTLOOK

Employment opportunities for urban planning and landscape architecture technicians are expected to be attractive, and to increase for the foreseeable future. In recent years, technicians have been one of the fastest growing occupational groups and it is expected that this rapid growth will continue. The necessity of providing American society with planned communities, renovated urban areas, attractively landscaped recreation areas, and aesthetically pleasing street vistas will continue to require the services of urban planning and landscape architecture technicians. The development, preservation, maintenance, and protection of land space resources are essential to the orderly growth of the nation.

SUGGESTED TECHNICAL CURRICULA

General Program Considerations

The objective of the total program of formal education for urban planning and landscape architecture technicians is to produce competent individuals capable of entering positions in urban planning or landscape architecture.

Because urban planning and landscape architecture technicians are employed in numerous and often specialized situations, the adequately trained technician must have attained the following abilities, scientific knowledge, and technical skills:

1. Facility with mathematics: The ability to use algebra and basic trigonometry as tools in the application of scientific principles related to problems in urban planning and landscape architecture.
2. Proficiency in the application of scientific principles, including the basic concepts of laws of chemistry and physics which are pertinent to land space resources.
3. An understanding of the materials, processes, and techniques commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the scientific activities that distinguish the technology of the field, such as the use of human behavior studies to design aesthetically pleasing new communities and techniques of using vegetation to reduce noise in the urban environment.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.[2]

The technical program has the usually recognizable five subject matter divisions, namely: (1) specialized courses in the technology; (2) auxiliary or supporting technical courses (such as technical report writing and technology orientation seminars); (3) mathematics courses; (4) science courses (such as chemistry and botany); and (5) general education courses. The technical subjects provide application of scientific and land space resources principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two semesters. General education courses constitute a relatively small part of the total program.

Curriculum Outline in Urban and Regional Planning Technology

COURSES

First Semester
- Communication Skills
- Elementary Social Science
- Physical Geography
- American History
- Applied Mathematics
- Physical Education
- Urban Planning Orientation Seminar

Second Semester
- Technical Reporting
- Cultural Geography
- Urban History
- Urban Sociology
- Engineering Graphics
- Elementary Probability and Statistics
- Physical Education

Work Experience
- On-the-Job Work Experience in Urban Planning: Work Program, 10-16 weeks duration at 40 hours per week, usually during the summer months.

Third Semester
- Urban Geography
- Cartography
- American Government Institutions
- Housing Development Process
- Man and His Environment
- Introduction to Computer Programming

Fourth Semester
- Community Development Process
- The Community: Power and Organization
- Psychology of Human Relations
- Survey and Analysis Techniques
- Techniques and Programs in Urban Planning
- Introduction to Data Processing Systems

Final Extended Field Trip
- Regional Urban Planning Practices – Three weeks of concentrated field observatio. at the end of the second year, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Communication Skills
A program designed to develop greater competence in reading, writing, speaking, and listening.

Elementary Social Science
An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society generally.

Physical Geography
A brief survey of the fundamental physical elements of geography. The nature and distribution of land forms, weather and climate, soils, vegetation, and other physical aspects of the earth are studied. Map study and interpretation form an important part of the course.

American History
History of the United States since 1865. An integrated survey emphasizing the emergence of a dominantly urban-industrial society; expanded role of government; America's increasing involvement in world affairs.

Applied Mathematics
A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles, identities, and equations in surveying. Basic statistical concepts of measures of central tendency and dispersion are illustrated.

Physical Education
Supervised recreational physical activities designed to promote coordination and physical fitness.

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[2] Adapted from *Criteria for Technician Education – A Suggested Guide*. OE-80056, Washington, DC: U.S. Government Printing Office, 1968, page 3.

Urban Planning Orientation Seminar

A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and urban planning personnel visits. Consideration is given to the broad historical aspects of urban development and planning in Europe and the United States, planning terminology, and urban planning policy at various levels. Current events in urban planning activities are discussed. Urban planning organizations at the various governmental levels are examined. A survey of the various kinds of occupations is made, and the demands and opportunities are stressed. Outside study is required. Urban planning programs, education, research, and future trends are analyzed. Representative lecturers from academia, industry, and government are invited to participate.

Second Semester

Technical Reporting

A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and form are emphasized.

Cultural Geography

An analysis of the basic cultural elements of geography. It includes the nature and distribution of population, as well as an introduction to man's use and location of agriculture, natural resources, industry, and transportation.

Urban History

This course will trace the development of the patterns which men have organized for living together in urban units. Special attention will be given to the functional bases of metropolitan forms of organization: the economic, political, social, and aesthetic needs of communities and the evolution of the modern city in response to these needs. Consideration will also be given to the critical needs of the modern city and the kinds of future developments which these imply.

Urban Sociology

Study of urban growth and development as they impinge upon groups and the individual. Familiarization with factors which characterize urban living and with problems facing the urban community.

Engineering Graphics

The graphical solution of space problems using the principles of orthographic projection, the geometry of points, lines, and surfaces, auxiliary views, pictorial views, intersections, and developments. Vector geometry, charts and graphs, curve fitting, and nomography are developed as aids to the analyses and communication methods by use of a design project, technical report, and oral presentation.

Elementary Probability and Statistics

A lecture and laboratory course which surveys the following areas: sampling methods, elementary probability, distribution theory, testing of hypotheses, analysis of variance, correlation, and linear regression.

Physical Education

A continuation of the first semester course.

Work Experience

On-the-Job Work Experience in Urban Planning

The student is given an introduction to the various activities involved in urban planning through employment with a governmental urban planning agency oftentimes during the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the urban planning principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The urban planning faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Urban Geography

A survey of the rise and growth of the city, its historical place in economic and ecological development. Urban population, land use, and mapping will be considered.

Cartography

A laboratory course on map design and construction. The art and science of creating small-scale and large-scale maps as a medium for communication and research.

American Government Institutions

Organization and operation of government at the national, state, and local levels and their responsibilities and activities which affect urban planning.

Housing Development Process

A course designed to expose the students to the physical and economic processes for housing development including the various funding grants available and the restrictive guidelines placed upon the construction of housing units by Federal agencies and local ordinances.

Man and His Environment

A discussion of man's relationship to his environment. Basic principles of evolution and ecology will be used to place the current ecological crisis in its proper biological perspective.

Introduction to Computer Programming using the basic program language

During the course, each student will prepare and run a number of computer programs of varying complexity.

Fourth Semester

Community Development Process

Concepts in environmental planning with emphasis on individual community problems in and around the area of the community college or technical institute.

The Community: Power and Organization

Study of the main community and nongovernmental agencies and volunteer organizations affecting the nature, character, and development of the metropolitan area. Emphasis on the interrelations of these groups as determinants of the total development of the urban community. Familiarization with their methods and techniques of operation.

Psychology of Human Relations

Introduction to general psychology and principles of human behavior. Techniques of persuasion, attitude formation, and change are demonstrated.

Survey and Analysis Techniques

A study of the principles and practices of gathering and interpreting demographic and geographic data for use in reports and proposals.

Techniques and Programs in Urban Planning

This course deals mainly with the content and methodology of basic studies in planning, the principles and techniques involved in preparing plans, the interrelationship of plans to form a comprehensive plan, and the programs and other devices used for implementing planning. Basic studies include population, land use, employment, and transportation. All major elements of the master plan will be studied as well as neighborhood planning, community planning, and regional planning. Implementation devices and programs to be covered include zoning, subdivision review, urban renewal and the capital improvement program.

Introduction to Data Processing Systems

An introduction to the basic principles and procedures for handling information, including use of electrical, mechanical, and punch-card equipment in the solution of business, mathematical, and scientific problems.

Final Extended Field Trip

Regional Urban Planning Practice

A three-week field trip to provide concentrated and varied field observation. it is conducted at the end of the fourth semester to give the student first-hand observation of the current urban planning programs and implementation methods in his region. This field trip supplements the on-the-job training experience of the previous summer.

Curriculum Outline in Landscape Architecture Technology

COURSES

First Semester
- Communication Skills
- Applied Mathematics
- Botany
- Elementary Social Science
- Elementary Soils
- Elementary Agricultural Chemistry
- Landscape Architecture Orientation Seminar

Second Semester
- Technical Reporting
- Technical Drawing
- Elementary Surveying
- Woody Plant Materials
- Advanced Soils
- Environmental Design I
- Urban History

Work Experience
- On-the-Job Work Experience in Landscape Architecture Technology: Work Program, 10-16 weeks duration at 40 hours per week, usually during the summer months.

Third Semester
- Engineering Graphics
- Environmental Design II
- Environmental Health I
- Soil Properties for Urban Development
- Landscape Equipment
- Outdoor Recreation

Fourth Semester
- Soil and Water Conservation
- Environmental Design III
- Environmental Health II
- Landscape Operations
- Landscape Construction
- Psychology of Human Relations

BRIEF DESCRIPTION OF COURSES

First Semester

Communication Skills

A program designed to develop greater competence in reading, writing, speaking, and listening.

Applied Mathematics

A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the application of right triangles, identities, and equations in surveying.

Botany

An elementary classroom and laboratory study of the forms and living processes of seed plants. It includes a study of the structure and function of roots, stems, leaves, flowers, and seeds. Metabolic processes and responses to stimuli, and a study of plant heredity are included.

Elementary Social Science

An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society generally.

Elementary Soils

A basic course in soil study to determine soil structure, soil chemistry, soil origin, soil types, soil organisms, and the recognition of soil components as they exist in nature. Laboratory exercises correspond to lecture material to provide a realistic understanding of soils.

Elementary Agricultural Chemistry

An elementary course in the theory and basic principles of inorganic and organic chemistry. Special emphasis is placed on the mineral elements essential to soil fertility.

Landscape Architecture Orientation Seminar

A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and landscape architecture personnel visits. Consideration is given to the broad historical development of landscape architecture principles and practices in Europe and the United States, landscape architecture terminology, and landscaping operations and policy at various levels. Current events in landscape architecture are discussed. Landscape architecture organizations at the various governmental and private business levels are examined. A survey of the various kinds of occupations is made, and the demands and opportunities are stressed. Outside study is required. Landscape architecture programs, education, research, and future trends are analyzed. Representative guest lecturers from academia, industry and government are invited to participate.

Second Semester

Technical Reporting

A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and form are emphasized.

Technical Drawing

A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce clear, legible, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting and landscape architecture activities.

Elementary Surveying

Plane and topographic surveying, error theory, curves, and earthwork as related to land surveying and landscape architecture operations. Laboratory consists of field practice with surveying instruments.

Woody Plant Materials

A detailed study of deciduous and evergreen trees, shrubs, and vines, their identification, growth habits, cultural requirements, and use in the landscape.

Advanced Soils

A detailed study of soil surveys, laboratory exercises in soil analyses for determining soil nutrient deficiences and soil structure; the determination of soil additives for maximum growth of woody ornamentals as well as cultural practices for proper soil tilth.

Environmental Design I

An introduction to the physical and environmental composition of the private and commercial landscape and recreational land areas. Emphasis is placed upon principles of design, use of plant materials, and psychological needs of people in order to achieve the optimum functional, economic, and aesthetic development of land areas.

Urban History

This course will trace the development of the patterns which men have organized for living together in urban units. Special

attention will be given to the functional bases of metropolitan forms of organization: the economic, political, social, and aesthetic needs of communities and the evolution of the modern city in response to these needs. Consideration will also be given to the critical needs of the modern city and the kinds of future developments which these imply.

Work Experience

On-the-Job Work Experience in Landscape Architecture

The student is given an introduction to various landscape architecture operations through employment with a landscape architecture organization, usually during the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the landscape architecture principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The landscape architecture technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Engineering Graphics

The graphical solution of space problems using the principles of orthographic projection, the geometry of points, lines, and surfaces, auxiliary views, pictorial views, intersections, and developments. Vector geometry, charts and graphs, curve fitting, and nomography are developed as aids to the analysis and communication methods by use of a design project, technical report, and oral presentation.

Environmental Design II

A continuation and expansion of Environmental Design I. Particular emphasis is given to the development of foundation plantings, patio areas, indoor garden design, and scale model construction. Laboratory experiences cover more complex design problems and techniques of interpretation.

Environmental Health I

An orientation to environmental health. The public health law and its administration, philosophy and history of environmental sanitation, and a basic exposure to several topics of concerns in public health, such as solid waste management and insect and rodent control.

Soil Properties for Urban Development

A classroom and laboratory course that stresses the physical properties of soils as the foundation for urban planning. Extensive use and interpretation of soil maps relating to land use are included.

Landscape Equipment

The problems and techniques of use of various hand tools and power machines designed for establishment and maintenance of landscape plantings are put into "hands on" practice.

Outdoor Recreation

A field oriented study of the use of parkland resources for recreation. The course is business oriented and includes a study of the demand for outdoor recreation, kinds of recreational enterprises, use of campgrounds and sport areas, and the selection, developing, managing, and merchandising of recreational enterprises.

Fourth Semester

Soil and Water Conservation

A study of the principles of conservation with emphasis on surveying, open and tile drainage systems, contouring, water impoundments, and mapping as they apply to soil and water conservation, parkland management, land use classification, land utilization for recreational purposes, and soil conservation organizations.

Environmental Design III

A series of urban and suburban recreational design studies involving a complexity of design elements including land use, ecological and circulation problems at the general level and spatial and natural relationships at the personal level.

Environmental Health II

A continuation of Environmental Health I emphasizing problems relating to housing facilities, recreational facilities, and radiological health.

Landscape Operations

A course which covers all aspects of establishing and maintaining a totally designed residential or community landscape. The course illustrates the practical applications of entomology, plant pathology, soil science, landscape construction, planting, and design.

Landscape Construction

Field surveying and staking, landscape grading, earthwork calculations, patio, wall, and fence installation, survey of construction materials, and elementary soil mechanics.

Psychology of Human Relations

Introduction to general psychology and principles of human behavior. Techniques of persuasion, attitude formation, and change are demonstrated.

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LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

American Institute of Planners
1776 Massachusetts Avenue, N.W.
Washington, DC 20036

American Society of Landscape Architects, Inc.
2013 I Street, N.W.
Washington, DC 20006

Soil Conservation Society of America
7515 N.E. Ankeny Road
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Chapter 8

WATER, WASTEWATER, AND OCEANOGRAPHIC TECHNOLOGIES

DEFINITION

Water is defined as the colorless, transparent liquid occurring on earth as rivers, lakes, oceans, etc., and falling from the clouds as rain. A chemical compound composed of hydrogen and oxygen (H_2O), water freezes at 32°F (0°C) and boils, forming steam, at 212°F (100°C). In its natural condition, water ranges from a nearly pure state in clouds and precipitation, through various concentrations of dissolved and suspended organic and inorganic matter and biota in streams, lakes, and rivers, to saline waters in the oceans and highly saline waters in certain seas and lakes lacking outlets.

SCOPE

The oceans cover more than 71 percent of the earth's surface to an average depth of about 2 1/2 miles. Two percent of the earth's surface is composed of fresh, inland waters. Estuarine waters along continental coastlines and freshwater wetlands (marshes, swamps, and bogs) also comprise important water resources.

ENVIRONMENTAL SIGNIFICANCE

Water is necessary for all life. It is the medium in which most of the metabolic processes of plants and animals occur. Water is one of the raw materials used in photosynthesis by green plants. The water of evapotranspiration and perspiration moderates high temperatures in plants and animals. It is the solvent utilized for transporting food materials within plants and animals. A sufficient supply of water is required to maintain high production of cultivated crops and livestock.

Water comprises 71 percent of a man's body weight. Two pints of water from catabolic oxidation and three pints of ingested water per day are required by a moderately active man in the temperate zone to replace the daily losses in perspiration, exhalation, and excretion.

The oceans, lakes, rivers, and streams and their associated shorelines provide part of man's food. The gathering of fish, wildlife, and aquatic plants has always provided sustenance to man. Water provided energy for machinery during the early phases of the industrial revolution and currently provides a portion of our electricity through hydroelectric installations. Oceans and inland waterways are important for transportation, commerce, and defense, as well as providing varied recreational activities. In the future, man will look to the oceans as a new source of food, biochemical agents, and minerals.

The earth's water supply remains constant. Water from ocean and land sources evaporates into the atmosphere and moves across the earth as water vapor. Water vapor condenses and falls to earth as precipitation which eventually returns to the ocean. This is called the water or hydrologic cycle. The amounts of water evaporated and precipitated are approximately equal. Every year about 80,000 cubic miles of water evaporates from oceans and about 15,000 cubic miles from land sources. Variation in water movements through the cycle – uneven distribution and irregular timing – causes most of the problems of local water excess or shortage.

The nation's renewable water resources are derived from an average annual precipitation of 30 inches, equivalent to 4,200 billion gallons per day on the conterminous United States. About 70 percent of this precipitation is consumed through evaporation and transpiration. A portion of this evapotranspiration provides 80 percent of our supply of food and fiber and nearly 100 percent of our forest products.
constitutes the nation's average annual runoff of about 9 inches or 1,200 billion gallons per day. This is the potential sustained supply for direct human use in homes, industries, irrigation, recreation, etc. It is about four times the average daily use now and about twice the predicted requirement in 1980.

Uneven distribution of water presents serious problems. Precipitation varies regionally, seasonally, and annually. Even greater variation can occur in streamflow. The availability of both surface and ground waters varies annually, seasonally, and over shorter periods of time. Floods and droughts of varying severity and duration are caused by extremes in precipitation. The amount of runoff that is available for development depends on the variability of the annual runoff, groundwater recharge possibilities, the storage capacity of reservoirs, and the evapotranspiration potential, all of which vary from basin to basin. Groundwater mining (well drilling and pumping) in some areas has augmented water supplies; however, this is only a temporary solution to meet local requirements and must ultimately cease as uneconomic pump lifts are reached or groundwater basins are exhausted. Desalinization may become a significant means of economically augmenting local water supplies under projected technology; however, its present utilization is limited. Induced precipitation, through weather modification, offers some possibilities for the future, but further research will be required. Other opportunities for augmenting natural runoff are through snowpack management, evaporation suppression, and the reduction of transpiration through manipulation of vegetation.

Natural water quality is affected by geologic, hydrologic, and biologic factors. The most significant natural impurities are sediment and dissolved minerals. The natural quality of water varies considerably among areas and, in specific localities, may make the water unfit for some uses. Man-caused pollution has seriously impaired water use over wide areas. This pollution consists primarily of (1) waste discharges for domestic, industrial, and agricultural uses; (2) sediment and other diffused wastes in runoff from urban, industrial, mining, and agricultural lands; (3) from logging; and (4) from transportation system developments. Changes in streamflow characteristics caused by upstream water control structures may also affect water quality.

The oceans cover about 71 percent of the earth's surface to an average depth of 2 1/2 miles, but only about 9 percent of this area has been even partially explored by man. Most of the explorations have been conducted on the continental shelves. The ocean's depth ranges from 600 feet or less above continental shelves to more than 35,000 feet at the Marianas Trench. The ocean bottom topography is similar to that of the continents, including the world's longest mountain range and tallest mountain.

Ninety percent of the photosynthesis on the earth's surface occurs in the oceans through the photochemical activities of phytoplankton and higher marine plants. More than a million different species of plants and animals live in the oceans. Marine biota are an important source of food for man.

Ocean currents, such as the Gulf Stream and Humboldt Current, have important biological and climatic effects on the continents. Physical reactions at the air-ocean boundary (interface) have as yet poorly understood effects of weather.

The oceans contain large amounts of dissolved minerals. The major constituents are: chlorine, sulfur, bromine, fluorine, sodium, magnesium, calcium, potassium, and strontium. Future technology may permit the economical mining of these minerals. Large oil deposits have been discovered under the ocean floor and over 16 percent of the world's oil now comes from sub-oceanic sources.

Man-caused pollution of the ocean from municipal and industrial wastes, pesticides, radioactive materials, heat, oil spills and various air pollutants is increasing as the human population continues to expand and the industrial revolution encompasses the underdeveloped nations. This pollution is especially detrimental to estuarine and marine biota.

The 1970s have been designated as the International Decade of Ocean Exploration and will involve both an accelerated study of the marine environment and a detailed assessment of the ocean's resources.

TECHNICAL POSITION REQUIREMENTS

Technicians who assist scientists engaged in the development, maintenance, regulation, and protection of water resources generally work in one of the following broad areas: (1) Water resources development, (2) Water supply and wastewater treatment, and (3) Oceanography.

Water resources development technicians assist hydrologists, limnologists, hydraulic engineers, and irrigation engineers to locate, develop, distribute, and maintain water resources. Wastewater treatment technicians assist water purification chemists, sanitarians, purification plant operators, water pollution control engineers, sanitation superintendents, and water-and-sewer systems superintendents to monitor, regulate and renovate wastewater. Oceanographic technicians assist physical, chemical, and geological oceanographers to gather basic knowledge about the world's largest water resource.

Recent technological advances in the management of water resources have created a serious shortage of highly trained technicians. Water resources management always has required and will continue to require a large amount of technical work in the area between the skilled workman and the professional scientist, engineer, and administrator. This technical work has usually been accomplished in the past by baccalaureate-level technologists, students working toward professional degrees, and other persons with or without formal training but with practical experience in some aspect of water resources and on-the-job training.

The water resources technician works under the general supervision of the professional water resources scientists or administrator. The technician is a person competent to occupy a responsible position in the line of authority between the skilled worker and the professional scientist. The technician often directs the activities of skilled workers. The water resources technician differs from the skilled worker in his theoretical and applied knowledge of water resources and from the scientist in his more limited or specialized background and in his use of technical skills in support of water resources management. The water resources technician requires an education and training sufficient to enable him to understand the reasons for, and the purposes of, the operation for which he is responsible.

A large number of skilled paraprofessional personnel have been employed in oceanography for several years. However, the need for formally educated technicians in water resources development and water supply and wastewater treatment is a comparatively recent development. Water resources development technicians assist scientists in discovering new sources of ground water, wise management of water supplies in reservoirs for domestic, industrial, and agricultural uses, and protection of water quality. The application of technology to reduce a sedimentation in water supplies and to distribute water supplies effectively from reservoirs is assuming greater importance as our water requirements expand.

Public concern for the quality of the environment has stimulated governmental action in environmental protection. Mounting concern about pollution of the nation's water resources led to the establishment of the Federal Water Pollution Control Administration in 1966, and expansion of the functions of Federal, state, and local water pollution control agencies. The establishment of the Environmental Protection Agency and the National Oceanic and Atmospheric Administration in 1970 illustrated the concern and commitment of the Federal government to improving environmental quality.

Competencies Required

Technicians who work with water resources must be capable of working and communicating with professional scientists, engineers and administrators as well as the skilled workers whom the technicians must supervise. Some technicians perform manipulative tasks while others supervise the application of such skills, but most do both. Their work is distinguished from that of the skilled worker primarily in that it is less repetitive, involves more objective analysis and problem solving, and requires an understanding of the principles of science, engineering, mathematics, and statistics in addition to their own particular skills in water resources technology.

Personal Qualities

Water resource technicians must be in good health. Searching for new sources of water, obtaining samples of industrial effluent for chemical analysis, or working as a crew member on an oceanographic research vessel require considerable physical stamina. Such personnel must enjoy working out-of-doors, sometimes in inclement weather. Technicians must be capable of carefully following directions from their superiors and communicating these directions to the skilled workers.

POSITION TITLES AND TYPICAL DUTIES

Water Resources Development

Hydrographic Technician. Measures rainfall and streamflow at metering stations, removes water samples for analysis and compiles hydrographic reports from findings. Lowers measuring device into water to obtain depth reading. Uses flowmeter to obtain rate of flow at surface and at various depths. Records depth and flow readings and computes mean cubic-foot-per-second flow using arithmetic and flow rating tables. Adjusts, calibrates, and maintains equipment which controls automatic water gates. Lowers silt sampler into river at damsite and canal stations for laboratory analysis. Obtains water samples from sludge pipes leading from desilting basin and computes amount of silt removed from water to determine efficiency of desilting basin. Prepares reports of hydrographic data.

Limnological Technician. Measures water temperature at various depths in lakes, streams, and ponds. Directs collection of samples of fresh waters and conducts laboratory analyses of oxygen content, turbidity, dissolved minerals, and suspended sediment. Supervises collection of bottom samples from lakes, streams, and ponds to determine the density and diversity of bottom-dwelling biota. Obtains sediment core samples from bottoms of fresh waters to determine physico-chemical and geological properties. Conducts surveys of surface and emergent vegetation. Prepares reports on limnological data.

Irrigation Technician. Supervises workers engaged in installation, regulation, maintenance, and operation of irrigation systems. Requires detailed technical knowledge of overhead, standpipe, valve pipe, and ditch type irrigation systems. Checks adequacy of water and fertilizer distribution on crops. Conducts periodic surveys to determine extent and quality of water resources available for irrigation. Serves as liaison between soil conservation district personnel and farmers and ranchers who are irrigating their land. Encourages practice of sound principles of soil and water conservation. Prepares reports on irrigation data.

Water Supply and Wastewater Treatment

Water Pollution Control Technician. Directs collection of water samples from reservoirs, streams, and lakes which are utilized for domestic, industrial, and recreational purposes. Transports samples to laboratory and conducts chemical analyses to determine the types and amounts of pollutants present. Coordinates sampling of industrial effluents and conducts field surveys to identify those industries which are polluting water resources in violation of Federal, state, and local ordinances. After sanitarians and water pollution control engineers have prescribed pollution abatement procedures, the technician helps the industries and municipalities to install, operate, and maintain the necessary water pollution control equipment. Technician installs equipment to monitor water pollution levels. Prepares reports on wastewater data.

Wastewater Treatment Technician. Operates wastewater treatment, sludge processing, and disposal equipment in wastewater treatment plant to control flow and processing of waste water. Monitors control panel and adjusts valves and gates manually or by remote control to regulate flow of wastewater. Observes variations in operating conditions and interprets meter and gauge readings, and tests results to determine load requirements. Supervises operation of pumps, engines, and generators to control flow rate of raw wastewater through settling, aeration, and sludge digestion processes. Maintains log of operations and records meter and gauge readings. Supervises sewage plant attendants and sewage disposal workers in performing routine operations and maintenance. May obtain sewage samples and perform routine laboratory tests. Prepares reports on wastewater treatment plant operation.

Water Treatment Technician. Controls treatment plant equipment to purify and clarify water for human consumption, recreational, and industrial uses. Controls flow of raw water into plant by starting and regulating operation of automatic equipment. Supervises addition of specified amounts of chlorine, ammonia, lime, or other chemicals to disinfect, deodorize, and clarify water or adjusts automatic devices which add chemicals in controlled dosages. Starts agitators to mix ingredients. Allows impurities precipitated by chemicals to settle to bottom of tank. Supervises removal of suspended impurities by filtering water through coal or sand beds. Directs pumping of purified water into water mains. Monitors control panel to determine rate of flow, loss of head, and water elevation and adjusts distribution of water. Directs maintenance and repair of equipment. Determines acidity and color of water by standard color reaction tests. Determines amount of impurities in water, using conductivity meter, and adding chemicals to coagulate impurities and reduce acidity. Records such data as residual chemical content, water turbidity, and water pressure, and prepares reports on these data.

Oceanography

Hydrographic Survey Technician. Operates standard surveying instruments such as bottom grabs, sextants, theodolites, depth recorders, wire drags, compasses, and other types of navigational and hydrographical equipment. Assists cartographer in drafting maps and reading charts. He assists with data collection and analyses using statistical procedures. The technician assists geological oceanographers to collect seismological and geomagnetic data. Prepares reports on oceanographic data.

Oceanographic Technician. Assists professional ocean scientists and engineers working in various specialties of oceanography, such as biology, chemistry, physics, and geology. Work consists of conducting a variety of chemical and physical analyses, such as tide and current studies, testing water for dissolved gases and solids, and studies of wave action. The technician calibrates, operates, and maintains numerous kinds of measuring, surveying, and sampling instruments used in oceanography. He must be capable of keeping records, plotting graphs and curves, and summarizing raw oceanographic data for interpretation by oceanographers, scientists, and engineers.

TYPES OF EMPLOYERS

Water Resources Development

Opportunities for employment for water resources development technicians exist in Federal, state, county and municipal governmental agencies.

Water resources development technicians may be employed by the large public agencies of the Federal government. The Soil Conservation Service of the U.S. Department of Agriculture employs technicians to aid in reducing hazards of floods and sedimentation, assuring the most efficient long-term use of soil and water, and establishing a more permanent and stable water supply. Technicians help scientists and engineers of the Bureau of Reclamation, U.S. Department of the Interior, to develop multi-purpose projects involving some or all of the functions of irrigation; hydro-electric power; municipal, industrial, and domestic water; flood control; navigation; fish and wildlife; recreation; water quality and pollution control. The Geological Survey (U.S.D.I.) employs technicians to help professional scientists to conduct hydrologic inventories, appraisals, and research on the water resources of the United States, its territories, and possessions. Other Federal agencies which employ water resources development technicians are: Farmers Home Administration; Department of Housing and Urban Development; Department of Health, Education, and Welfare; Department of Commerce; Office of Water Resources Research; Office of Saline Waters; Bureau of Land Management; Bureau of Commercial Fisheries; Bureau of Sport Fisheries and Wildlife; National Park Service; Forest Service; Agricultural Research Service; Atomic Energy Commission; Weather Bureau; Bonneville Power Administration; and Tennessee Valley Authority. Some paraprofessional positions with Federal agencies are in the classified civil service. The U.S. Civil Service Commission gives entrance examinations each year. Advancement is based on ability.

Organization for water resources development varies from one state to another. According to a recent survey by the Council of State Governments, responsibilities are distributed among more than 200 state agencies in the 50 states. Examples of such agencies are: Department of Environmental Resources; Department of Agriculture; Department of Health; and Department of Recreation. State positions are usually classified civil service posts and require a rating on a competitive entrance examination.

Employment opportunities also exist with many county or municipal governments which are large enough to have responsibility for water supplies.

Universities, colleges, and junior colleges which offer water and wastewater related curricula including environmental engineering, need research, teacher, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff.

Water resources development technicians employed by the Federal government usually receive a starting salary of about $6,500 per year. Technicians who demonstrate the ability to do more responsible work are promoted to higher grade positions. State, county, and municipal government positions usually pay slightly lower salaries than Federal government positions.

Wastewater Treatment

Employment opportunities for wastewater treatment technicians exist in Federal, state, county, and municipal governmental agencies, and with numerous wastewater equipment manufacturing firms.

Wastewater treatment technicians may be employed in regulating and consulting functions by the various organizations of the Environmental Protection Agency. Some permanent paraprofessional positions with the Federal government are in the classified civil service. The U.S. Civil Service Commission gives entrance examinations each year. Advancement is based on ability.

Wastewater treatment technicians may find employment at the state level with the Department of Environmental Resources, Department of Health, and Department of Urban Development. State positions are usually classified civil service posts. A survey of

wastewater treatment plant operator certification in the United States which was conducted by the Water Pollution Control Federation in 1970 revealed that 47 states require certification and 27 states require some kind of formal education of wastewater treatment plant operators.

Many employment opportunities exist with county or municipal governments which have the responsibility for treatment of their municipal, industrial, and domestic wastewater.

Many employment opportunities for technicians are found with industries which manufacture water pollution control and monitoring equipment and with consulting engineering firms.

Universities, colleges, and junior colleges which offer water and wastewater related curricula including environmental engineering, need research, teacher, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff.

Annual starting salaries for wastewater treatment technicians employed by Federal and state governments are about $6,500, while technicians employed by local governments start at an annual salary of about $6,000. Applicants showing superior academic achievement may start at higher salaries. Salaries with industries and consulting firms are comparable to those paid by Federal and state governments.

Oceanography

Oceanographic technicians generally secure employment with marine industries, marine laboratories, or among various agencies of the state and Federal governments.

Oceanographic technicians may be employed by the large public agencies of the Federal government. Many technicians are employed by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. This organization, established in 1970, includes the following agencies: Weather Bureau, Coast and Geodetic Survey, Environmental Data Service, National Environmental Satellite Center, Bureau of Commercial Fisheries, Marine Game Fish Research Program, Marine Mineral Technology Center, the Navy-administered National Oceanographic Data Center and National Oceanographic Instrumentation Center, the Coast Guard's National Data Buoy Development Project, and the National Science Foundation's Sea Grant Program. Other positions are available with the Navy Oceanographic Office and the Army Corps of Engineers of the Department of Defense.

There is a rapidly growing demand for technicians in many industries directly and indirectly concerned with marine science and engineering. Industries such as petroleum, natural gas, and precious stone mining conduct marine operations. Oceanographic consulting firms and fishing industries employ technicians. Industry is becoming a major developer of oceanographic equipment and instruments; technicians are needed to test these products in the marine environment.

Universities, colleges, and junior colleges which offer curricula in oceanography and oceanographic technologies need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff.

Annual starting salaries for oceanographic technicians with the Federal government are about $6,500; industrial salaries are comparable to those of the Federal government.

EMPLOYMENT OUTLOOK

Employment opportunities for technicians trained to work in water resources development, wastewater treatment, and oceanography are expected to be attractive and to increase for the foreseeable future. In recent years, technicians have been one of the fastest growing occupational groups and it is expected that this rapid growth will continue. The manpower needs in the area of water resources development have not been determined but are believed to be extensive. According to the Water Quality Office of the Environmental Protection Agency, a minimum of 45,000 wastewater treatment plant operators will be required by 1980 – three times the number that were available in 1967. The U.S. Public Health Service estimates that half of the personnel currently operating wastewater treatment plants are inadequately trained. The accelerated study of the marine environment and the detailed assessment of the ocean's resources which have been fostered by designating the 1970's as the International Decade of Ocean Exploration will create many employment opportunities for oceanographic technicians.

The necessity of providing the nation with an adequate supply of high quality water for industrial, municipal, and domestic uses will continue to require the services of water resources development technicians. Water pollution has become a nationwide crisis and the expanding efforts to ameliorate this problem have ensured a bright future for wastewater treatment technicians. The development of the physical, chemical, and biological resources of the oceans to meet the needs of an expanding world population and an increasingly complex industrial world economy will require large numbers of oceanographic technicians.

SUGGESTED TECHNICAL CURRICULA

General Program Considerations

The objective of the total program of formal education for water resources technicians is to produce competent individuals capable of entering any of several closely related positions within one of the water resource areas: water resources development, wastewater treatment, or oceanography.

Because water resources technicians are employed in numerous and often specialized situations, the adequately trained technician must have attained the following abilities, scientific knowledge, and technical skills:

1. Facility with mathematics: The ability to use algebra and basic trigonometry as tools in the application of scientific principles related to problems in water resources. A basic knowledge of statistical methods is required.
2. Proficiency in the application of scientific principles, including the basic concepts and laws of chemistry, physics, and biology which are pertinent to water resources.
3. An understanding of the materials, processes, and techniques commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the scientific activities that distinguish the technology of the field, such as water sampling methods, use of biological pollution indicators, and analysis of sediment cores.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.[1]

The technical program has the usually recognizable five subject matter divisions, namely: (1) specialized courses in the technology; (2) auxiliary or supporting technical courses (such as technical report writing and water resources technology seminars); (3) mathematics courses; (4) science courses (such as geology and soils); and (5) general education courses. The technical subjects provide application of scientific and water resources principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two terms. General education courses constitute a relatively small part of the total program.

Curriculum Outline in Water Resources Development Technology

COURSES

First Semester

Elementary Inorganic Chemistry

[1] **Adapted** from *Criteria for Technician Education - A Suggested Guide.* OE-80056, Washington, DC: U.S. Government Printing Office, 1968, page 3.

Communication Skills
Elementary Botany
Applied Mathematics
Applied Soils
Water Resources Development Orientation Seminar

Second semester
Technical Drawing
Elementary Social Science
Elementary Zoology
Elementary Surveying
Applied Analytical Chemistry

Work Experience
On-the-Job Work Experience in some area of Water Resources Development: Work Programs, 10-16 weeks duration at 40 hours per week, usually during the summer.

Third Semester
Technical Reporting
Applied Structural Engineering
Water Resources Equipment and Measurements
Applied Hydrology
Elementary Limnology

Fourth Semester
Applied Meteorology
Outdoor Water Recreation Management
Applied Geology
American Government Institutions
Irrigation and Soil and Water Conservation

Final Extended Field Trip
Regional Water Resources Development - Three weeks of concentrated field observation at the close of the second year, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Inorganic Chemistry
An elementary course in the theory and basic principles of inorganic chemistry. Special emphasis is placed on chemical equations; properties of solutions and colloids, and other principles basic to chemical analysis.

Communication Skills
A program designed to develop greater competence in reading, writing, speaking, and listening.

Elementary Botany
An elementary classroom and laboratory study of the forms and living processes of plants. It includes basic concepts of plant morphology, physiology, and development. Special emphasis is placed on aquatic plants and plant species which affect human health.

Applied Mathematics
A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles, identities, and equations in surveying. Basic statistical concepts of measures of central tendency and dispersion are illustrated.

Applied Soils
A basic course in soil study covering soil structure, soil chemistry, soil water and soil water movement, soil origin, soil types, soil organisms, and the recognition of soil components and soil properties as they exist in nature. Special emphasis is placed on the relationship of soil to water resources.

Water Resources Development Technology Orientation Seminar
A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and lectures by water resources development personnel. Consideration is given to the history of water resources development in Europe and the United States, water resources terminology, and water resources management policy at various levels. Current events in water resources development are discussed. Water resources organizations at the various governmental levels are examined. A survey of the various kinds of occupations is made and the demands and opportunities are stressed. Outside study is required. Water resources development programs, education, research, and future trends are analyzed. Representative guest lecturers from industry and government are invited to participate.

Second Semester

Technical Drawing
A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce legible, clear, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting.

Elementary Social Science
An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society generally.

Elementary Zoology
An elementary classroom and laboratory study of the forms and living processes of animals. It includes basic concepts of animal morphology, physiology, and development. Special emphasis is placed on aquatic animals and animal species which affect human health.

Elementary Surveying
Plane and topographic surveying, error theory, curves, and earth-work as related to land surveying, water control structures, and watershed mapping. The laboratory consists of field practice with surveying instruments.

Applied Analytical Chemistry
A classroom and laboratory study of the theories, methods, and instruments of qualitative and quantitative chemical analysis of water.

Work Experience

On-the-Job Work Experience in Water Resources Development Technology
The student is given an introduction to various areas of water resources development technology through employment with a water resources organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the water resources development principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The water resources development faculty keeps close contact with the student and his employers. A highly structured program and regular reports by the student add depth to the work experience.

Third Semester

Technical Reporting
A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Appropriate forms, conciseness, and accuracy are emphasized.

Applied Structural Engineering
Application of principles, methods, and equipment to the construction of various water control structures, such as dams, weirs, dikes, and aqueducts.

Water Resources Equipment and Measurement

A classroom and laboratory study of the various types of instruments used to measure the physical and chemical properties of water resources. The course will include the installation, calibration, maintenance, and repair of equipment such as rain gauges, lysimeters, pH meters, current meters, and weirs.

Applied Hydrology

A general survey of the waters of the earth, their occurrence, circulation, and distribution, their chemical and physical properties, and interrelationships of their biotic and abiotic components.

Elementary Limnology

A classroom and laboratory study of the biological, physical, and chemical properties of lakes and ponds with a special reference to the effects of these properties on aquatic plants and animals.

Fourth Semester

Applied Meteorology

Selected topics on meteorological phenomena and their effects on climate, weather, and water resources.

Outdoor Water Recreation Management

A field oriented study of the use of water resources for recreation. The course includes studies of the development, maintenance, and management of recreational enterprises in which water is the predominant resource.

Applied Geology

A survey of surface geologic processes: Weathering, sedimentation and sedimentary rocks, stream regimen, ground water, wind action, glaciation, and shoreline processes.

American Government Institutions

Organization and operation of governmental organizations at the national, state, and local levels and their responsibilities and activities which affect the utilization of water resources.

Irrigation and Soil and Water Conservation

Includes the importance of irrigation in crop production; methods of irrigation; amounts of moisture required for optimum plant growth; and conservation practices to conserve soil and moisture in crop production.

Final Extended Field Trip

Regional Water Resources Development Practices

A three-week trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current water resources development practices in his region. This field trip supplements the on-the-job training experience of the previous summer.

Curriculum Outline in Water and Wastewater Treatment Technology

COURSES

First Semester
- Introduction to Wastewater Technology and Related Fields
- Applied Mathematics I
- Physics I (Heat and Mechanics)
- General Drafting
- Communication Skills

Second Semester
- Applied Mathematics II
- Technical Reporting
- Basic Hydraulics for Wastewater
- Microbiology for Wastewater
- Physics II (Electricity and Light)

Work Experience

On-the-Job Experience in Water and Wastewater Treatment: Work Program, 10-16 weeks duration at 40 hours per week, usually during the summer.

Third Semester
- Sanitary Chemistry and Microbiology I
- Water Supply and Wastewater Control
- Water Purification
- *Surveying*
- General and Industrial Economics

Fourth Semester
- Sanitary Chemistry and Microbiology II
- Wastewater Treatment
- Instrumentation and Controls
- Contracts, Specifications, Codes, and Estimates and Costs
- Industrial Organizations, Institutions, and Government

Final Extended Field Trip

Regional Wastewater Treatment - Three weeks of concentrated field observation at the close of the second year, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Introduction to Water and Wastewater Technology and Related Fields

A study of methods of disease transmission, hygienic excreta disposal, municipal and industrial wastewater collection and treatment, characteristics of water, water treatment, protection of ground water, insect and rodent control, solid waste collection and disposal, milk and food sanitation, swimming pool sanitation, and industrial hygiene.

Applied Mathematics I

A course in algebra, analytic geometry, and introductory trigonometry, with particular stress on slopes and rates of change and the determination of maxima and minima conditions.

Physics I (Heat and Mechanics)

A study of the basic principles of mechanics and heat, with the emphasis in both laboratory and lecture on the scientific method. Laboratory-oriented to provide application of principles learned in the mathematics course, including use of the slide rule for computation of data.

General Drafting

A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to provide an elementary understanding of: orthographic projection; isometric and oblique sketching; detail and assembly of working drawings; principles and applications of descriptive geometry to drawings; plane, profile and topographic drawing; how to use handbooks and other resource materials. Interpretation of industrial sketches and prints is introduced.

Communication Skills

A program designed to increase competence in reading, writing, speaking, and comprehension of oral instructions.

Second Semester

Applied Mathematics II

A continuation of mathematics I which completes the study of necessary principles of analytic geometry and concludes with introductory phases of calculus required for optimum performance in hydraulics and process control.

Technical Reporting

A study of effective ways of presenting information, with emphasis on the use of graphs, drawings, sketches, and outlines for various types of oral presentations and written reports.

Basic Hydraulics for Water and Wastewater Technology

A basic study of closed conduit and open channel flow, including stream flow, subterranean flow, runoff, pump characteristics, and wave action.

Microbiology for Water and Wastewater Technology

A basic course in microbiology with emphasis on microorganisms, and on the laboratory procedures for identifying

and differentiating organisms peculiar to water and wastewater treatment, and related public health and stream sanitation problems.

Physics II (Electricity and Light)

A study of the basic principles of electricity, electrical circuitry, motors, and light, emphasizing the concepts of physics and laboratory-oriented to provide application of principles.

Work Experience

On-the-Job Experience in Wastewater Treatment Technology

The student is given an introduction to various aspects of wastewater treatment technology through employment with a wastewater treatment facility, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the wastewater treatment principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. the wastewater treatment faculty keeps close contact with the student and his employers. Regular reports by the student add depth to the experience.

Third Semester

Sanitary Chemistry and Microbiology I

Theory and laboratory techniques for all control tests of water purification including: bacteriology, color, turbidity, pH, alkalinity, hardness, coagulations, chlorides, fluorides, iron, maganese, detergents, bactericides, and nitrates. It includes basic "in-plant" studies at nearby wastewater treatment plants.

Water Supply and Wastewater Control

A course designed to familiarize the student with the elementary engineering aspects of water supply and distribution; and wastewater collection, removal, and disposal.

Water Purification

A study of basic principles of water purification including: aeration sedimentation, rapid sand filtration, chlorination, treatment chemicals, taste and odor control, bacteriological control, mineral control, design criteria, maintenance programs, and operational problems. New processes and recent developments are studied. Criteria, rules, regulations, forms, and records associated with the field are considered.

Surveying

A study of the elementary theory and practice of plane surveying including taping, differential and profile leveling, cross sections, earth-work computations; and transit, stadia, and transitape surveys.

General and Industrial Economics

A study of the principles of general and industrial economics; an analysis of the factors involved and the importance of cost control in an industrial or municipal enterprise.

Fourth Semester

Sanitary Chemistry and Microbiology II

A study of the theory and laboratory techniques for the determination of solids, dissolved oxygen, oxygen consumed, relative stability, bacteria, biochemical oxygen demand, organic nitrogen, voltatile acids, and toxic metals in liquid media. This course includes stream studies and in-plant studies.

Wastewater Treatment

This course is designed to familiarize the student with the elementary engineering aspects of design, operation, process control, and maintenance of wastewater treatment plants and facilities.

Instrumentation and Controls

An elementary study of hydraulic, pneumatic, mechanical. electrical and electronic control systems and components. It includes a basic description, analysis, and explanation of operation of instruments and controls for water and wastewater plants. Typical performance characteristics, accuracy, and applications of instruments are studied.

Contracts, Specifications, Codes, Estimates and Costs

A course designed to teach the methods and procedures of developing an engineering contract with code and cost limitations.

Industrial Organizations, Institutions, and Government

A study of the roles of labor and management in the development of American industry. Analysis is made of forces affecting labor supply, employment, and industrial relations in a democratic system of government.

Final Extended Field Trip

Regional Wastewater Treatment Practices

A three-week trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current wastewater treatment practices in his region. This field trip supplements the on-the-job training experience of the previous summer.

Curriculum Outline in Oceanographic Technology

COURSES

First Semester
- Elementary Oceanography
- Communication Skills
- Applied Chemistry
- Applied Mathematics
- Basic Photography

Second Semester
- Elementary Biology
- Technical Drawing
- Applied Physics
- Elementary Surveying
- *Basic Computer Programming *or* Underwater Photography

Work Experience

On-the-Job Work Experience in Oceanography: Work Program, 10-16 weeks duration at 40 hours per week, usually during the summer.

Third Semester
- Elementary Marine Biology
- Physical and Geological Oceanography
- Survey of Navigation
- Electronics for Technicians
- *Elementary Mineralogy *or* Introductory Scuba Diving

Fourth Semester
- Elementary Marine Biology
- Instrumentation and Methods of Oceanography
- Chemical Oceanography
- Technical Reporting
- *Elementary Probability and Statistics *or* Advanced Scuba Diving

Final Extended Field Trip

Regional Oceanographic Practices - Three weeks of concentrated field observation of regional oceanographic research vessels and on-shore laboratories at the close of the second year, at 40 hours per week.

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*Students who are not physically able or who do not wish to work underwater should elect Basic Computer Programming, Elementary Mineralogy, and Elementary Probability and Statistics in place of Underwater Photography, and the two Scuba Diving courses. Students who are physically able and desirous of underwater work should elect the latter three courses.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Oceanography
A general survey course. Measurable physical, chemical, and geological parameters of the ocean environment are defined. Potential uses of the sea are considered. The significance of the sea to trade, transportation, and defense is discussed. Major geomorphological features of the ocean bottom are studied.

Communication Skills
A program designed to develop greater competency in reading, writing, speaking, and listening.

Applied Chemistry
An elementary course in the theory and basic principles of inorganic chemistry. Special emphasis is placed on the mineral elements which are found dissolved in ocean water. Elementary aspects of qualitative chemical analysis are demonstrated.

Applied Mathematics
A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the application of right triangles, identities, and equations in surveying. Basic statistical concepts of measures of central tendency and dispersion are illustrated.

Basic Photography
A laboratory course in basic camera manipulation and darkroom techniques. Development of skills necessary to take and develop acceptable black and white photographs are stressed. Techniques of color photography are introduced.

Second Semester

Elementary Biology
A lecture and laboratory course which provides an inclusive survey of living organisms. Origin, development, and cellular basis of life. Study of fundamental principles, processes, structures, and taxonomy of living organisms. Examination of reproduction, genetics, evolution, and diversity.

Technical Drawing
A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and free-hand sketching, the ability to understand detail and assemble working drawings, and to produce clear, legible, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting.

Applied Physics
An elementary survey course covering the basic principles and concepts of mechanics, wave motion, sound, electricity, magnetism, heat, and optics.

Elementary Surveying
Plane surveying methods. Use of engineer's level, transit, and tape. Topographic surveying, error theory, and curves.

Basic Computer Programming
Computer components and organization, representations of numbers and characters, instruction codes, machine language, programming, assembly systems, input - output, and subroutines.

Underwater Photography
A laboratory course in equipment and techniques of underwater photography.

Work Experience

On-the-Job Work Experience in Oceanography
The student is given an introduction to the various fields of oceanography through employment with an oceanographic organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the oceanography principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The oceanography faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Elementary Marine Biology
A general survey of marine fauna and flora and their ecological relationships, with special emphasis on the marine life near the oceanographic technology institution.

Physical and Geological Oceanography
A lecture and laboratory course covering the physical processes and geomorphological features of the marine environment. Emphasis will be given to wave theory and shoreline processes.

Survey of Navigation
Basic concepts and principles of navigation. Content will include basic definitions, charts, nautical instruments for piloting, gyro and magnetic compasses, and visual and electronic aids to navigation. An ocean vessel is used for practice in navigation.

Electronics for Technicians
Basic AC, DC, and electronic theory are surveyed. Practical uses of electronics in marine, chemical, and biological equipment is stressed.

Elementary Mineralogy
Principles of element distribution and crystallography. Mineralogy, texture, occurrence, and origin of igneous and metamorphic rocks.

Introductory Scuba Diving
Development of basic skills and safety procedures for scuba diving. This course will be taught in ocean waters near the institutions.

Fourth Semester

Elementary Marine Ecology
A lecture and laboratory course in the study of the interrelationships and interdependencies of organisms, populations, and communities. Energy flow, production, and applications for human consumption are stressed.

Instrumentation and Methods of Oceanography
A laboratory course in which the student will learn to operate oceanographic instruments and to manipulate sampling devices. Classes will be held on both oceanographic vessels and laboratories ashore.

Chemical Oceanography
A laboratory course on the use of chemical and analytical methods pertinent to chemical studies of sea water.

Technical Reporting
A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and appropriate form are emphasized.

Elementary Probability and Statistics
A lecture and laboratory course which surveys the following areas: sampling methods, elementary probability, distribution theory, testing of hypotheses, analysis of variance, correlation, and linear regression.

Advanced Scuba Diving
A lecture and laboratory course covering first aid for divers, underwater navigation, deep diving, underwater tows, mixed-gas diving, and physics and physiology of deep-water diving.

Final Extended Field Trip

Regional Oceanographic Practices

A three-week trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current oceanographic practices in his region. This field trip supplements the on-the-job training experience of the previous summer.

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U.S. Department of the Interior, Federal Water Quality Administration. *Clean Water for the 1970's - A Status Report.* Washington: U.S. Government Printing Office, 1970.

LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

American Academy of Environmental Engineering
P.O. Box 9728
Washington, DC 20016

American Geophysical Union
2100 Pennsylvania Avenue, N.W.
Washington, DC 20037

American Meteorological Society
45 Beacon Street
Boston, MA 02108

American Society of Limnology and Oceanography, Inc.
c/o Department of Zoology
University of Michigan
Ann Arbor, MI 48104

American Water Works Association, Inc.
2 Park Avenue
New York, NY 10016

National Association of Sanitarians
University of Denver
Denver, CO 80203

National Rivers and Harbors Congress
1028 Connecticut Avenue, N.W.
Washington, DC 20036

Water Pollution Control Federation
3900 Wisconsin Avenue, N.W.
Washington, DC 20016

Chapter 9
WILDLIFE, FISH, AND MARINE LIFE TECHNOLOGIES DEFINITION

DEFINITION

Organisms classified under the natural resource "fish" in this publicaton include the bony and cartilaginous fishes, molluscs, and crustaceans. Organisms classified under the natural resource "wildlife" include amphibians, reptiles, birds, and mammals. "Marine life" includes all species of marine plants and animals.

SCOPE

Populations of fish are found throughout the world in marine, estuarine, and fresh-water habitats. Populations of wildlife are worldwide in distribution, occupying marine, estuarine, fresh-water, and terrestrial habitats. Marine animals and plants are also worldwide in distribution, inhabiting oceanic and estuarine waters.

ENVIRONMENTAL SIGNIFICANCE

The European settlers who migrated to North America in the seventeenth century found a continent teeming with vast fish and wildlife resources. Climax vegetation covered the continent, except for scattered pyric subclimax areas derived from lightning or from deliberate burning by Indians and subclimax areas derived from hurricanes, floods, and other catastrophic natural disturbances. Certain wildlife species had evolved large and widely distributed populations within each vegetative climax: the passenger pigeon in the eastern hardwood forest; the buffalo in the western grasslands; the javelina in the semi-arid Southwest. The more productive rivers, streams, and lakes abounded with fish and crustaceans, while the estuaries and continental shelf waters supported large populations of fish, crustaceans, and shellfish.

The settlers considered the fish and wildlife population to be limitless resources which could be exploited indefinitely for meat, furs, and feathers. The passenger pigeon was exterminated by market hunters and changes in vegetation around 1900. The slaughter of the vast buffalo herds was encouraged by the Federal government as part of the pacification program against the Indians, who were dependent upon the buffalo herds. Competition with livestock, fencing, and farming also contributed to the decline of the buffalo. By 1880, the buffalo population which once numbered in the millions had been reduced to a few hundred animals. Protests against wildlife slaughter were initiated around the middle of the nineteenth century by sport hunters and biologists who wished to preserve America's fauna for recreational and scientific purposes. Game protective associations or sporting clubs were established in most of the states by 1900.

By 1870, public interest in fish and wildlife resources began to evoke activity by the Federal government. Congress established the U.S. Fishery Commisission in 1871 to conduct scientific studies on the maintenance and development of fisheries resources. Similar agencies were soon established by the states and the responsibilities of these agencies were gradually expanded to include studies of birds and mammals. The Biological Survey Office of the U.S. Department of Agriculture was established in the 1890's to study wildlife problems.

The establishment of wildlife refuges was initiated by the creation of Yellowstone National Park in 1872, in which hunting, except for predatory animals, and logging were excluded. The buffalo evaded extinction because of a small herd which lived in Yellowstone Park, and some small remnant herds in Canada. Thirteen million acres of western public lands were incorporated into forest preserves by President Benjamin Harrison in 1891. The United States Bureau of Fisheries established the first national wildlife refuge in 1892 at Afognak Island, Alaska, to protect salmon, sea lions, and sea otters.

In 1900 Congress passed the Lacey Act which prohibited the interstate shipment of wild game taken in violation of state laws and empowered the Biological Survey as the enforcement agency. This law effectively destroyed the commercial hunting trade.

Theodore Roosevelt had been an effective advocate of the conservation of wildlife and other natural resources for decades. When Vice President Roosevelt acceded to the Presidency in 1901, he immediately acted to strengthen Federal agencies involved in conserving natural resources. Roosevelt conferred police powers on the Biological Survey and established the U.S. Forest Service. Under Roosevelt's leadership, many millions of acres were added to the forest preserves (National Forests) and to national wildlife refuges. President Roosevelt called a state governor's conference in 1908 to promote wildlife conservation activities.

All migratory birds and other endangered wildlife species were placed under Federal protection when President Woodrow Wilson promulgated the Migratory Bird Treaty with Great Britain in 1918. A major drought serously threatened migratory waterfowl species in the early 1930s. This emergency prompted President F.D. Roosevelt to request Congress to establish the Duck Stamp Act or 1934, which required all adult hunters of waterfowl to buy a federal stamp. These funds were used to purchase waterfowl refuges and for waterfowl research and refuge management.

Federal Cooperative Wildlife Research units were established at state land-grant colleges beginning in 1935. Each unit was staffed with federal wildlife research personnel. The Bureau of Fisheries and the Biological Survey were combined in 1936 to form the U.S. Fish and Wildlife Service of the U.S. Department of the Interior. This agency conducts research on fish and wildlife and manages the Federal wildlife refuges.

By 1920, nearly all of the states required hunters and fishermen to purchase licenses. These funds were used for acquisition of state game preserves, establishment of fish hatcheries, and wildlife research. Federal funds (the Pittman-Robertson Federal Aid in Wildlife Restoration Act, and the Dingell-Johnson Federal Aid to State Fisheries Act) derived from taxes on sporting arms, ammunition, and fishing equipment supplement state funds for fish and wildlife research, land acquisition, and management.

In retrospect, we now know that wildlife needs food, water, suitable cover, and freedom from disturbance for survival. It is probable that the destruction of the virgin forest habitat of the passenger pigeon was more important in the extinction of this species than were the depredations of the market hunters. Suitable habitat changes have permitted enormous increases in white tailed deer and prong-horned antelope populations from the remnant populations existing at the turn of the century. Exotic species, such as the carp and Chinese ringnecked pheasant, have been successfully established in suitable habitats in many areas of the United States.

The environmental side effects of our modern industrialized society pose an insidious threat to our fish and wildlife resources. Contamination of air, water, and soil resources by industrial pollutants, municipal sewage, and pesticides have caused serious mortality and a decline in vigor and fecundity among many fish and wildlife populations. The conversion of wildlands to agricultural uses, cities, industrial sites, and transportation facilities have reduced the acreage of fish and wildlife habitat. The combined effects of environmental pollution, habitat destruction, mismanagement, and poaching have caused the decline of the populations of more than 100 species of fish and wildlife to levels where they are threatened with extinction. Once common species, such as bald eagles and alligators, are among these endangered species. Species which are designated as endangered are now protected under Federal law. The American people are hopeful that enlightened fish and wildlife management and the protection of Federal law will preserve our fish and wildlife resources for the enjoyment of future generations.

Marine fishes and mammals have been utilized for food by maritime peoples for thousands of years. The marine life resources of the ocean constitute a common property natural resource which may be simultaneously utilized by nations, industries, and individuals.

The industrial revolution and man's expanding population have caused a continuing expansion of the exploitation of marine life resources. Whales and seals were ruthlessly slaughtered during the nineteenth century and well into the twentieth century before conservation efforts became effective. Large numbers of modern fishing and whaling vessels, with their sophisticated electronic searching equipment and effective harvesting equipment are capable of seriously depleting populations of marine fishes and mammals. International agreements have been signed in order to manage whale, seal, and various fish populations on a sustained yield basis. Examples of such international conventions are the International Whaling Convention (1931) and a subsequent Protocol (1946); the Interim Convention on Conservation of the Northern Pacific Fur Seals (1957) and the Inter-American Tropical Tuna Commission (1950). Many marine biologists feel that efforts to save many whale species from extinction will not be successful.

Marine life resources will continue to be an important source of protein for an expanding human population only if we learn to manage these resources on a sustained yield basis. Additional research contributing to the conservation of these valuable marine resources will be required.

TECHNICAL POSITION REQUIREMENTS

Technicians who assist scientists and managers engaged in the development, maintenance, regulation, and protection of fish and wildlife resources generally work in one of the following broad areas: (1) wildlife resources, (2) fisheries resources, and (3) marine life resources.

Wildlife resources technicians assist wildlife biologists, game commissioners, game farm managers, farmers, ranchers, foresters, and park managers to locate, inventory, develop, distribute, and maintain wildlife resources. Fisheries resources technicians assist fisheries scientists, fish commissioners, fish hatchery superintendents, farmers, ranchers, and park managers to locate, inventory, develop, distribute, and maintain fisheries resources. Marine life resources technicians assist marine biologists, biological oceanographers, marine aquarium managers, and commercial shellfish growers to study, propagate, increase, and maintain marine life resources.

Recent technological advances in the management of fish and wildlife resources have created a moderate shortage of highly trained technicians. Fish and wildlife management always have required, and will continue to require, a large amount of technical work in the area between the skilled workmen and the professional scientist and managers. This technical work has usually been done in the past by baccalaureate-level technologists, students working toward professional degrees, and other persons with or without formal training but with practical experience in some aspect of fish and wildlife resources together with on-the-job training.

The fish and wildlife resources technician works under the general supervision of the professional fish and wildlife resources scientist or manager. The technician is a person competent to occupy a responsible position in the line of authority between the skilled worker and the professional man. The technician often directs the activities of skilled workers. The fish and wildlife resources technician differs from the skilled worker in his theoretical and applied knowledge of fish and wildlife resources and differs from the professional man in his more limited or specialized background and in his use of technical skills in support of fish and wildlife resources management. The technician requires an education and training sufficient to enable him to understand the reasons for, and the purposes of, the operations for which he is responsible.

Competencies Required

Technicians who work with fish and wildlife resources mut be capable of working and communicating with professional scientists, managers, and administrators as well as the skilled workers whom the technicians must supervise. Some technicians perform manipulative tasks while others supervise the application of such skills, but most do both. Their work is distinguished from that of the skilled worker primarily in that it is less repetitive, involves more objective analysis and problem solving, and requires an understanding of the principles of science, engineering, mathematics, and statistics in addition to their own particular skills in fish and wildlife resources technology.

Personal Qualities

Fish and wildlife resource technicians must be in good health. Conducting field surveys of wildlife populations, conducting a census of the fish population in a pond by the mark and recapture method, or working as a crew member of a marine biology research vessel require considerable physical stamina. Such personnel must enjoy working out-of-doors, sometimes in inclement weather.

POSITION TITLES AND TYPICAL DUTIES

Wildlife Resources Technology

Wildlife Conservation Technician. Supervises crews of skilled workmen in fighting fires, planting wildlife food plants, cutting forest stands to stimulate stump sprouting, and excavating springs and ponds to improve wildlife water supplies. Surveys and supervises construction of roads and trails used for both access of fire-fighting equipment and for visitors to parks and wildlife preserves. Conducts surveys of wildlife populations and vegetative use, condition, and trend. Protects endangered species of wildlife and their habitats. Writes reports on wildlife data and prepares maps on locations of wildlife, food, and cover vegetation.

Wildlife Research Technician. Aids wildlife biologists in studies of wildlife nutrition, behavior, physiology, and reproduction. Captures wildlife species for study, marking, and transferring from one area to another. Supervises crews engaged in the introduction of exotic species of wildlife. Conducts opinion surveys of visitors to parks and wildlife preserves. Uses sophisticated equipment, such as telemetering receivers, to follow movements of individual animals. Summarizes and writes reports on wildlife data.

Game Warden. Patrols his assigned area to prevent game law violations, investigates reports of damage to crops and property by wildlife, and compiles biological data. Travels through area by car, boat, airplane, horse, or on foot to observe persons engaged in taking game, to insure method and equipment used are lawful, and to apprehend violators. Investigates reports of game law violations and issues warnings and citations. Serves warrants, makes arrests, and prepares and presents evidence in court action. Seizes equipment used in game law violations and arranges for disposition of game illegally taken or possessed. Investigates hunting accidents and files reports of findings. Assists in promoting hunter safety training by arranging for materials and instructors.

Fisheries Resources Technology

Fish Conservation Technician. Supervises crews of skilled workmen in planting cover vegetation on streambanks to prevent erosion and provide shade, construction of baffles, gabions, trash catchers, and other stream modifications to improve habitat for fish and fish food organisms, construction of fish ladders around dams, and maintenance of roads, dikes, and equipment. Conducts surveys of fish populations using techniques such as the mark and recapture method, and creel census. Protects endangered species of fish and their habitat. Writes reports on fisheries resources data and prepares maps of lakes and streams showing depth, flow-rate, temperature, bottom-types, and presence and extent of pollution.

Fish Research Technician. Aids fisheries biologists in studies of fish nutrition, behavior, physiology, and reproduction. Captures fish species for study, marking, and transferring from one area to another. Supervises crews engaged in the introduction of exotic species of fish. Conducts biological studies of fish population structure, recording such data as age, size, fecundity of females, and stomach contents. Studies daily and seasonal movements and feeding habits of fish population. Assists in management of fish and crustacean populations. Collects and compiles fisheries resources data and prepares reports of findings for fisheries biologists.

Fish Hatchery Manager. Supervises skilled workmen engaged in cultivating fish for use in stocking streams and ponds. Studies water conditions where fish of various species breed and spawn, and directs emulation of such conditions in hatchery ponds. Develops techniques for collecting, fertilizing, and incubating of spawn (fish eggs). Oversees treatment of spawn and fry (offspring). Supervises protection of fish in the hatchery from predators and parasites. Supervises activities of workers engaged in feeding and sorting of fish, and liberation, transfer, or distribution of fish for stocking streams and ponds.

Fish Warden. Patrols his assigned area to prevent fish law violations and collects biological data. Travels through area by car, boat, airplane, horse, or on foot to observe persons engaged in taking fish, to insure method and equipment used are lawful and to apprehend violators. Investigates reports of fish law violations and issues warnings and citations. Serves warrants, makes arrests, and prepares and presents evidence in court actions. Seizes equipment used in fish law violations and arranges for disposition of fish illegally taken or possessed. May obtain samples of fish from creels of fishermen for studies by fisheries biologists.

Marine Life Technology

Marine Life Technician. Assists marine biologists and biological oceanographers in studies of the nutrition, behavior, physiology, reproduction, and ecology of marine animals. Captures marine specimens for study, marking, and transferring from one area to another. Conducts biological studies of the structure of marine animal population, obtaining such data as age, size, health, fecundity of females, and stomach contents. Studies daily and and seasonal movements and feeding habits of marine crustaceans, molluscs, reptiles, fish, birds, and mammals. Assists in management of marine animal populations. May study marine flora utilized for food by marine fauna. Collects and compiles marine life resources data and prepares reports of findings for marine biologists and biological oceanographers. May work on oceanographic research vessels or at on-shore laboratories.

TYPES OF EMPLOYERS

Wildlife Resources

Opportunities fro employment for wildlife resources technicians exist in Federal and state government agencies, in educational institutions, and in private organizations and industries.

Wildlife resources technicians may be employed by the large public agencies of the Federal government. The following Bureaus within the U.S. Department of the Interior employ wildlife resources technicians: Land Management, Outdoor Recreation, Indian Affairs, Sport Fisheries and Wildlife, and Reclamation. The National Park Service, U.S. Dapartment of the Interior, also employs wildlife resources Technicians. Other Federal employers are the Forest Service and Extension Service in the U.S. Department of Agriculture. Most paraprofessional positions with Federal agencies are in the classified civil service. The U.S. Civil Service Commission gives entrance examinations each year. Advancement is usually based on ability.

State governments are the largest employers of wildlife resources technicians. These positions are located in state conservation agencies such as the Department of Natural Resources, Department of Fish and Game, Department of Environmental Resources, Department of Parks and Recreation, and Department of Agriculture. State positions are usually classified civil service posts which require a rating on a competitive entrance examination.

Limited employment opportunities exist with county and municipal governments which are large enough to have responsibilities for extensive wildlands which are managed as forests, parks, or watersheds.

Universities, colleges, and junior colleges which offer curricula in wildlife management or wildlife resources technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff and may range in academic rank from research aide to technical assistant.

A small number of large private utilities and land-holding corporations engaged in lumber, paper, and mining operations employ wildlife resources technicians. Large private hunting clubs and private game farms also employ technicians. Some limited employment opportunities for technicians are found with private research laboratories, zoos, museums, and community nature or conservation centers.

Wildlife resources technicians employed by the Federal government usually receive a starting salary of about $6,000 per year. Positions with private organizations are generally comparable in salary with Federal government positions, while academic and state and municipal government positions usually pay slightly lower salaries. Technicians who demonstrate the ability to do more responsible work are promoted to higher salaried positions.

Fisheries Resources Technology

Opportunities for employment for fisheries resources technicians exist in Federal and state governmental agencies, in educational institutions, and in private organizations and industries.

Fisheries resources technicians may be employed by the large public agencies of the Federal government. The Bureau of National Marine Fisheries of the U.S. Department of Commerce and the Bureau of Sport Fisheries and Wildlife of the U.S. Department of the Interior are the major Federal employers of fisheries resources technicians. Other Federal employers of limited numbers of technicians are the Army Corps of Engineers, Bureau of Outdoor Recreation, Forest Service, National Park Service, Public Health Service, and Environmental Protection Agency. Most paraprofessional positions with Federal agencies are in the classified civil service. The U.S. Civil Service Commission gives entrance examinations each year. Advancement is usually based on ability.

State governments are the largest employers of fisheries resources technicians. These positions are located in state conservation agencies such as the Department of Natural Resources, Department of Fish and Game, Department of Environmental Resources, Department of Parks and Recreation, and Department of Agriculture. State positions are usually classified civil service posts and require a rating on a competitive entrance examination.

Limited employment opportunities exist with county and municipal governments which are large enough to have responsibilities for extensive water resources which are managed as reservoirs, recreation fishing, or watersheds.

Universities, colleges, and junior colleges which offer curricula in fisheries science or fisheries resources technology need research, teaching, and extension assistants to aid their professional faculty. These technical poistions are generally classified as staff and may range in academic rank from research aide to technical assistant.

A small number of private fish hatcheries, bait farms, fishing clubs, zoos, aquariums, museums, and community nature or conservation centers employ fishereies resources technicians.

Marine Life Technology

Marine life technicians generally secure employement with marine industries or among various agencies of state and Federal governments.

Marine life technicians may be employed by the large public agencies of the Federal government. Many technicians are employed by the National Oceanic Atmospheric Administration of the U.S. Department of Commerce in the following agencies: Coast and Geodetic Survey, National Marine Fisheries, Marine Game Fish Research Program, the Navy-administered National Oceanographic Data Center, and the National Science Foundation Sea Grant Program. Other positions are available with the Navy Oceanographic Office of the Department of Defense.

Some limited employment opportunities exist with state governments in states which are located on the coasts. State Fisheries agencies often manage oyster beds and fish habitats in bays, estuaries, and the continental shelf.

Universities, colleges, and junior colleges which offer curricula in biological oceanography or marine life technology need research, teaching, and extension assistants to aid their professional faculty. These technical positions are generally classified as staff and may range in academic rank from research aide to technical assistant.

A number of industries engaged in research and development of marine life resources employ technicians. Examples of areas of work are the maintenance and expansion of oyster beds, collection of marine specimens for biological supply houses, collection of marine specimens for pharamaceutical studies, and development of commercial algae beds. Technicians may also find work with marine aquaria, zoos, and museums.

Marine life technicians employed by the Federal government usually receive a starting salary of about $6,000 per year. Positions with industrial and private organizations are generally comparable in salary with Federal government positions, while academic and state government positions usually pay slightly lower salaries. Technicians who demonstarte the ability to do more responsible work are promoted to higher salaried positions.

EMPLOYMENT OUTLOOK

Employment opportunities for technicians trained to work in wildlife, fisheries, and marine life resources are expected to increase moderately for the forseeable future. In recent years, technicians have been one of the fastest growing occupational groups and it is expected that this rapid growth will continue. The increased popularity of recreational hunting and fishing will result in an increased demand for wildlife and fisheries resources technicians. The accelerated study of the marine environment and the detailed assessment of the ocean's resources which have been fostered by designating the 1970s as the International Decade of Ocean Exploration will create many employment opportunities for marine life technicians.

SUGGESTED TECHNICAL CURRICULA

General Program Considerations

The objective of the total program of formal education for wildlife and fisheries resources technicians is to produce competent individuals capable of entering any of several closely related positions within one of the wildlife and fisheries resources areas: wildlife resources, fisheries resources, or marine life resources.

Because wildlife and fisheries resources technicians are employed in numerous and often specialized situations, the adequately trained technician must have attained the following abilities, scientific knowledge, and technical skills:

1. Facility with mathematics: The ability to use algebra and basic trigonometry as tools in the application of scientific principles related to problems in wildlife and fisheries resources. A basic knowledge of statistical methods is required.
2. Proficiency in the application of scientific principles, including the basic concepts and laws of chemistry, physics, and biology which are pertinent to wildlife and fisheries resources.
3. An understanding of the materials, processes, and techniques commonly used in the technology.
4. An extensive knowledge of a field of specialization with an understanding of the scientific activities that distinguish the technology of the field, such as wildlife population census, methods of marking fish, or correct use of marine bottom sampling equipment.
5. Communication skills that include the ability to interpret, analyze, and transmit facts and ideas graphically, orally, and in writing.[1]

The technical program has the usually recognizable five subject matter divisions, namely: (1) specialized courses in the technology; (2) auxiliary or supporting technical courses (such as technical report writing, wildlife and fisheries resources technology seminars); (3) mathematics courses; (4) science courses (such as biology and chemistry); and (5) general education courses. The technical subjects provide application of scientific and wildlife and fisheries resources principles. For this reason, mathematics and science courses must be coordinated carefully with technical courses at all stages of the program. This coordination is accomplished by scheduling mathematics, science, and technical courses concurrently during the first two semesters. General education courses constitute a relatively small part of the total program.

Curriculum Outline in Wildlife Technology

COURSES

First Semester
- Elementary Forest and Range Surveying
- Communication Skills
- Applied Mathematics
- Botany
- Elementary Soils
- Wildlife Technology Orientation Seminar

Second Semester
- Technical Reporting
- Food and Cover Plants of Forest and Range
- Technical Drawing
- Zoology
- American Government Institutions
- Elementary Chemistry

Work Experience
- On-the-Job Work Experience in the Wildlife Technology Field: Usually a summer program, 10-16 weeks duration at 40 hours per week.

Third Semester
- Principles of Ecology
- Natural History of Vertebrates
- Aerial Photo-Interpretation
- Elements of Forest and Range Management
- Principles of Wildlife Conservation

Fourth Semester
- Wildlife Management
- Wildlife Law Enforcement and Public Relations
- Elements of Social Science
- Wildlife Field and Laboratory Techniques
- Outdoor Recreation

Final Extended Field Trip
- Regional Wildlife Management Practices: Three weeks of concentrated field observation at the close of the second year, at 40 hours per week.

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[1] Adapted from *Criteria for Technician Education–A Suggested Guide* OE-80056. Washington, DC: U.S. Government Printing Office, 1968, page 3.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Forest and Range Surveying

An elementary course in the theory and basic principles of plane surveying emphasizing practical laboratory and field application in forest and range surveying.

Communication Skills

A program designed to develop greater competence in reading, writing, speaking, and listening.

Applied Mathematics

A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles, identities, and equations in surveying. Basic statistical concepts of measures of central tendency and dispersion are illustrated.

Botany

An elementary classroom and laboratory study of the forms and living processes of seed plants. It includes a study of the structure and function of roots, stems, leaves, flowers, and seeds. Physiological processes and responses to stimuli, and a study of plant heredity are included.

Elementary Soils

A basic course in soil study to determine soil structure, soil chemistry, soil origin, soil types, soil organisms, and the recognition of soil components as they exist in nature. Laboratory exercises correspond to lecture material to provide a realistic understanding of soils.

Wildlife Technology Orientation Seminar

A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and wildlife resources personnel visits. Consideration is given to the broad historical aspects of wildlife resources development and conservation in Europe and the United States, wildlife terminology, and wildlife management policy at various levels. Current events in wildlife conservation are discussed. Wildlife resources organizations at the various governmental levels are examined. A survey of the various kinds of occupations is made, and the demands and opportunities are stressed. Outside study is required. Wildlife resources programs, education, research, and future trends are analyzed. Representative guest lecturers from academia, industry, and government are invited to participate.

Second Semester

Technical Reporting

A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and form are emphasized.

Food and Cover Plants of Forest and Range

A survey of the woody and herbaceous plant species occurring in forest and rangeland communities which provide food and cover to wildlife. Plant identification and autecology will be stressed.

Technical Drawing

A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce clear, legible, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting and wildlife habitat management activities.

Zoology

An elementary classroom and laboratory study of the forms and living processes of animals. Morphology, physiology, development, taxonomy, life history, and evolution of animals will be covered.

American Government Institutions

Organization and operation of governmental organizations at the national, state, and local levels and their responsibilities and activities which affect wildlife resources.

Elementary Chemistry

An elementary course in the theory and basic principles of inorganic and organic chemistry. Introductory concepts of the nature of matter, elements, compounds, chemical bonding, and solution dynamics with special emphasis on the study of organic compounds and their relationship to the biochemistry of living organisms.

Work Experience

On-the-Job Work Experience in Wildlife Technology

The student is given an introduction to various areas of wildlife technology through employement with a wildlife resources organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the wildlife technology principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The wildlife technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Principles of Ecology

A classroom and laboratory study of the relationships of plants and animals to their biological and physical environment. Concepts of succession, climax, ecological dominance, environmental resistance, inter-and intra-species competition, territoriality, trophic levels, and population structure are included.

Natural History of Vertebrates

A classroom and laboratory study of the taxonomy and life history of the major vertebrate groups. General ecological requirements, reproductive habits, distribution, and habitat preferences are emphasized for each of the vertebrate classes.

Aerial Photo-Interpretation

An introduction to the principles and practices of interpreting aerial photography, with emphasis on types of vegatation, mapping, and wildlife inventory techniques.

Elements of Forest and Rangeland Management

Methods of managing forests and rangelands for multiple use objectives (wood, water, wildlife, forage, and recreation), with special emphasis on manipulating vegetation to increase wildlife populations.

Principles of Wildlife Conservation

A classroom and laboratory study of the legal, physical, and biological aspects of wildlife conservation. The historical development of fish and wildlife conservation in the United States is surveyed.

Fourth Semester

Wildlife Management

A classroom and laboratory study of the application of wildlife management techniques. The course will cover wildlife census techniques, capture and marking of wildlife, habitat evaluation, and the application of wildlife management principles as they relate to important recreational resources.

Wildlife Law Enforcement and Public Relations

A presentation and interpretation of Federal and state rules and regulations as they apply to hunting and fishing in the United States. The role of the conservation biologist and

game protector are discussed in relation to the legislative enactment and the enforcement of these laws. The importance of public relations in law enforcement activities will be emphasized.

Elements of Social Science

An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles, and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society in general.

Wildlife Field and Laboratory Techniques

Methods for the care and treatment of animals under laboratory conditions, including feeding, breeding, and rearing of mammals, birds, and reptiles. The use of wildlife anesthetics, techniques in sexing and aging, and laboratory data collection systems are also covered. Practicums in necropsy and parasite identification are also included.

Outdoor Recreation

A field oriented study of the use of wildlife resources for recreation. The course includes the study of the demand for outdoor recreation, trends in hunting, use of campgrounds and sport areas, and growth of nature study and wildlife photography.

Final Extended Field Trip

Regional Wildlife Management Practices

A three-week field trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current wildlife management practices in his region. This field observation supplements the on-the-job training experience and permits him to observe wildlife management practices, game propagation, and wildlife habitat protection techniques which he has studied but may not have seen in operation.

Curriculum Outline in Fisheries Technology

COURSES

First Semester
- Elementary Chemistry
- Communication Skills
- Applied Mathematics
- Technical Drawing
- Elementary Zoology
- Fisheries Technology Orientation Seminar

Second Semester
- Technical Reporting
- Invertebrate Zoology
- Elementary Surveying
- American Government Institutions
- Elementary Soils
- Applied Structural Engineering

Work Experience
- On-the-Job Work Experience in some area of Fisheries Resources: Usually a summer program, 10-16 weeks duration at 40 hours per week.

Third Semester
- Aquatic Botany
- Water Resources Equipment and Measurements
- Elementary Limnology
- Natural History of Fishes
- Elements of Oceanography

Fourth Semester
- Outdoor Water Recreation Management
- Elementary Social Science
- Fisheries Biology Techniques
- Fisheries Resources Management
- Applied Hydrology

Final Extended Field Trip

Regional Fisheries Resources Practices—Three weeks of concentrated field observation at the close of the second year, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Chemistry

An elementary course in the theory and basic principles of inorganic and organic chemistry, introductory concepts of the nature of matter, elements, compounds, chemical bonding, and solution dynamics with special emphasis on the study of organic compounds and their relationship to the biochemistry of living organisms.

Communication Skills

A program designed to develop greater competence in reading, writing, speaking, and listening.

Applied Mathematics

A course in basic algebraic concepts, radicals, and exponents, with an introduction to graphic and trigonometric functions of angles, particularly as they relate to the applications of right triangles identities, and equations in surveying. Basic statistical concepts of measures of central tendency and dispersion are illustrated.

Technical Drawing

A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce clear, legible, and neat drafting work using current drafting tools and techniques. Topographic drawing and freehand lettering are stressed as requirements for map drafting and fisheries management activities.

Elementary Zoology

An elementary classroom and laboratory study of the forms and living processes of animals. Morphology, physiology, development, taxonomy, life history, and evolution of animals will be covered.

Fisheries Technology Orientation Seminar

A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and fisheries resources personnel visits. Consideration is given to the broad historical aspects of fisheries resources development and conservation in Europe and the United States, fisheries terminology, and fisheries management policy at various levels. Current events in fisheries resources conservation are discussed. Fisheries resources organizations at the various governmental levels are examined. A survey of the various kinds of occupations is made, and the demands and opportunities are stressed. Outside study is required. Fisheries resources programs, education, research, and future trends are analyzed. Representative guest lecturers from academia, industry, and government are invited to participate.

Second Semester

Technical Reporting

A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Conciseness, accuracy, and form are emphasized.

Invertebrate Zoology

Classroom and laboratory study of the forms and living processes of invertebrate animals. Taxonomy, morphology, and life history will be covered. Invertebrate animals which interact as food supply, parasites, or predators of fish will be emphasized.

Elementary Surveying

Plane and topographic surveying, error theory, curves, and earth work as related to land surveying, water control structures, and watershed mapping. The laboratory consists of field practice with surveying instruments.

American Government Institutions

Organization and operation of governmental organizations at the national, state, and local levels and their responsibilities and activities which affect fisheries resources.

Elementary Soils

A basic course in soil study to determine soil structure, soil chemistry, soil origin, soil types, soil organisms, and the recognition of soil components as they exist in nature. Laboratory exercises correspond to lecture material to provide a realistic understanding of soils.

Applied Structural Engineering

Application of principles, methods, and equipment to the construction of various water control structures, such as dams, weirs, dikes, and aqueducts.

Work Experience

On-the-Job Work Experience in Fisheries Technology

The student is given an introduction to various areas of fisheries technology through employment with a fisheries resources organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the fisheries technology principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The fisheries technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Aquatic Botany

A classroom and laboratory study of aquatic flora. Morphology, taxonomy, and habitat requirements of aquatic plants are covered. Special emphasis is placed on plant species which are important food sources for fish and for animals that fish eat.

Water Resources Equipment and Measurements

A classroom and laboratory study of the various types of instruments used to measure the physical and chemical properties of water resources. The course will include the installation, calibration, maintenance, and repair of equipment such as rain gauges, pH meters, lysimeters, current meters, and weirs.

Elementary Limnology

A classroom and laboratory study of the geographical, physical, and chemical properties of lakes and ponds with special reference to the effects of these properties on aquatic plants and animals.

Natural History of Fishes

Taxonomy and life history of the major species of fresh water, marine, and anadromous fish (those which spawn in fresh water streams and migrate to the oceans or the Great Lakes). General ecological requirements, reproductive habits, distribution, and habitat preferences are emphasized for each species.

Elements of Oceanography

A general survey course. Measurable physical, chemical, and geological parameters of the ocean environment are defined. Potential uses of the sea are considered. Major geomorphological features of the ocean bottoms are studied.

Fourth Semester

Outdoor Water Recreation Management

A field-oriented study of the use of water resources for recreation. The course includes studies of the development, maintenance, and management of recreational enterprises in which water is the predominant resource.

Elementary Social Science

An introductory study of the social sciences, beginning with man as an individual, his cultures, social organization, and stratification. It continues with a study of social control principles and problems of individuals and of society. The objective of the course is to provide the student with a general understanding of people and how they function as individuals, in social groups, and in society generally.

Fisheries Biology Techniques

This course covers a wide range of laboratory techniques in fisheries and water resources. Students are taught the care and treatment of fish under laboratory conditions, techniques used in sexing and aging, laboratory data collection systems, maintenance of aquariums, and use of analytical instruments in water quality analyses. Practicums in necropsy and parasite identification are included.

Fisheries Resources Management

A classroom and laboratory course covering the application of fish management principles. Creel census, population estimation techniques, age and growth studies, watershed evaluation, fish life history features, stream and lake improvement, fish hatchery procedures, and fish stocking and propagation are studied.

Applied Hydrology

A general survey of the waters of the earth, their occurrence, circulation, and distribution, their chemical and physical properties, and interrelationships of their biotic components.

Final Extended Field Trip

Regional Fisheries Resources Management Practices

A three-week field trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current fisheries development, research, management, and conservation practices in his region. This field trip supplements the on-the-job training experience and permits the student to observe fisheries technology practices which he has studied, but may not have seen in operation.

Curriculum Outline in Marine Life Technology

COURSES

First Semester

- Elementary Oceanography
- Elementary Chemistry
- Applied Mathematics
- Elementary Zoology
- *Technical Drawing *or* Introductory Scuba Diving
- Marine Life Technology Orientation Seminar

Second Semester

- Technical Reporting
- Communication Skills
- Applied Physics
- Biology of Marine Invertebrates
- American Government Institutions
- *Elementary Probability and Statistics *or* Advanced Scuba Diving

Work Experience

On-the-Job Work Experience in Marine Life Technology: Usually a summer program, 10-16 weeks at 40 hours per week.

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*Students who are not physically able or who do not wish to work under water should elect Technical Drawing and Elementary Probability and Statistics in place of Introductory and Advanced Scuba Diving. Students who are physically able and desirous of underwater work should elect the two scuba diving courses.

Third Semester
- Introductory Marine Ecology
- Physical and Geological Oceanography
- Marine Plants
- Natural History of Marine Fishes
- Natural History of Marine Mammals

Fourth Semester
- Advanced Marine Ecology
- Chemical Oceanography
- Instrumentation and Methods of Oceanography
- Marine Plants
- Techniques of Marine Biology
- Marine Fisheries Management

Final Extended Field Trip
- Regional Marine Life Technology Practices–Three weeks of concentrated field observation of marine life research, management, and conservation practices of his region, at 40 hours per week.

BRIEF DESCRIPTION OF COURSES

First Semester

Elementary Oceanography
A general survey course. Measurable physical, chemical and geological parameters of the ocean environment are defined. Potential uses of the sea are considered. Major geomorphological features of the oceans bottom are studied.

Elementary Chemistry
An elementary course in the theory and basic principles of inorganic chemistry. Introductory concepts of the nature of matter, elements, compounds, chemical bonding, and solution dynamics with special emphasis on the study of organic compounds and their relationship to the biochemistry of living organisms.

Applied Mathematics
A course in algebra, analytic geometry, and trigonometry with particular stress on slopes and rates of change and the determination of maxima and minima conditions.

Elementary Zoology
An elementary classroom and laboratory study of the forms and living processes of animals. Morphology, physiology development, taxonomy, life history, and evolution of animals will be covered.

Technical Drawing
A beginning course for students who have had little or no previous experience in drafting. The principal objectives are to introduce a basic understanding of orthographic projection and freehand sketching, the ability to understand detail and assemble working drawings, and to produce clear, legible, and neat drafting work using current drafting tools and techniques.

Introductory Scuba Diving
Development of basic skills and safety procedures for scuba diving. This course will include experience in ocean waters near the institution. (This is usually taught in a swimming pool for safety in diving and mastery of skills!)

Marine Life Technology Orientation Seminar
A course designed to orient the beginning student in a post-high school education program. The student is given occupational and professional orientation by means of panel reports and lectures by marine life resources personnel. Consideration is given to the broad historical development of marine life research in the United States, marine life terminology, and marine life management policy at various levels. Current events in marine life resources are discussed. Marine life resources organizations at the various governmental levels are examined. A survey of the various kinds of occupations is made and the demands and opportunities are stressed. Outside study is required. Marine life resources education, research, and future trends are analyzed. Representative guest lecturers from academia, industry, and government are invited to participate.

Second Semester

Technical Reporting
A study of effective ways of presenting information. The student learns the utility of illustrations and outlines for various types of oral and written, formal and informal reports. Appropriate form, conciseness, and accuracy are emphasized.

Communication Skills
A program designed to develop greater competence in reading, writing, speaking, and listening.

Applied Physics
An elementary survey course covering the basic principles and concepts of mechanics, wave motion, sound, electricity, magnetism, heat, and optics.

Biology of Marine Invertebrates
A classroom and laboratory study of the taxonomy and life history of the marine invertebrates. General ecological requirements, reproductive habits, distribution, and habitat preferences are emphasized for each of the marine invertebrate groups.

American Government Institutions
Organization and operation of governmental organizations at the national, state, and local levels and their responsibilities and activities which affect marine life resources.

Elementary Probability and Statistics
A lecture and laboratory course which surveys the following areas: sampling methods, elementary probability, distribution theory, testing of hypotheses, analysis of variance, correlation, and linear regression.

Advanced Scuba Diving
A lecture and laboratory course covering safety and first aid for divers, underwater navigation, deep diving, underwater tows, mixed-gas diving, and physics and physiology of deep-water diving.

Work Experience

On-the-Job Work Experience in Marine Life Resources
The student is given an introduction to the various areas of marine life technology through employment with a marine life resources organization, usually in the summer months between his freshman and sophomore years. This occupational experience is very important since it provides the student with the opportunity to practice and observe the application of some of the marine life technology principles he has learned, to comprehend the need for much more learning, and to be more perceptive in the courses which follow in the third and fourth semesters. The marine life technology faculty keeps close contact with the student and his employer. Regular reports by the student add depth to the experience.

Third Semester

Introductory Marine Ecology
A classroom and laboratory study of the relationships of marine plants and animals to their biological and physical environment. Autecological phenomena are stressed. Intraspecific competition, limiting factors, and population dynamics are included.

Physical and Geological Oceanography
A lecture and laboratory course covering the physical processes and geomorphological features of the marine environment. Emphasis will be given to wave theory and shoreline processes.

Marine Plants
A lecture and laboratory course covering marine flora. Marine vegetation of the shoreline, continental shelf bottom, and surface waters will be studied. It includes basic concepts of

plant morphology, taxonomy, physiology, and development. Special emphasis is placed on marine plants which are food resources for marine animals.

Natural History of Marine Fishes

Taxonomy and life history of the major species of marine and anadromous fishes (those which spawn in fresh water streams and migrate to the oceans). General ecological requirements, reproductive habits, distribution, and habitat preferences are emphasized for each species.

Natural History of Marine Mammals

Taxonomy and life history of the major species of marine mammals. General ecological requirements, reproductive habits, distribution, and habitat preferences are emphasized for each species.

Fourth Semester

Advanced Marine Ecology

A classroom and laboratory study of the relationships of marine plants and animals to the biotic and abiotic components of their environment. Synecological phenomena are stressed. Concepts of ecological dominance, environmental resistance, interspecies competition, trophic levels, and energy interrelationships in marine communities are included.

Chemical Oceanography

A laboratory course on the use of chemical and analytical methods pertinent to chemical studies of sea water.

Instrumentation and Methods of Occanography

A laboratory course in which the student will learn to operate oceanographic instruments and to manipulate sampling devices. Classes will be held both on oceanographic vessels and in laboratories ashore.

Techniques of Marine Biology

This course covers a wide range of laboratory techniques in marine biology. Students are taught the care and treatment of fish and animals under laboratory conditions, techniques used in sexing and aging, maintenance of aquariums, use of anesthetics, data collection, and correct use of water and bottom sampling equipment. Practicums in necropsy and parasite identification are also included.

Marine Fisheries Management

A classroom and laboratory course covering the application of marine fish management principles. Population estimation techniques, age and growth studies, methods of determining population structure, fish life history features, fish hatchery procedures, and fish propagation are studied.

Final Extended Field Trip

Regional Marine Life Resources Practices

A three-week trip to provide concentrated and varied field observation. It is conducted at the end of the fourth semester to give the student first-hand observation of the current marine life resources practices in his region. This field trip supplements the on-the-job training experience.

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Trefethen, James B. *Wildlife Management and Conservation.* Boston: DC Health & Co., 1964.

LIST OF SELECTED PROFESSIONAL AND TECHNICAL ORGANIZATIONS

American Fisheries Society
1040 Washington Building
15th Street and New York Avenue
Washington, DC 20005

American Institute of Biological Sciences
3900 Wisconsin Avenue, N.W.
Washington, DC 20016

Society of American Foresters
1010 Sixteenth Street, N.W.
Washington, DC 20036

Society for Range Management
Suite 201
2120 South Birch Street
Denver, CO 80222

The Wildlife Society
Suite S 176
3400 Wisconsin Avenue, N.W.
Washington, DC 20016

Wildlife Management Institute
709 Wire Building
Washington, DC 20005